TUGAS AKHIR – TI 141501

PENELITIAN KONVERSI SAMPAH DI KOTA SURABAYA

RACHMASARI
NRP 2512 100 016

Pembimbing
Dr. Maria Anityasari
NIP. 19701120 199703 2 001

JURUSAN TEKNIK INDUSTRI
FAKULTAS TEKNOLOGI INDUSTRI
INSTITUT TEKNOLOGI SEPULUH NOPEMBER SURABAYA
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FINAL REPORT
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STUDY OF SOLID WASTE CONVERSION IN SURABAYA MUNICIPALITY

RACHMASARI
NRP 2512 100 016

Supervisor
Dr. Maria Anityasari
NIP. 19701120 199703 2 001

DEPARTMENT OF INDUSTRIAL ENGINEERING
FACULTY OF INDUSTRIAL TECHNOLOGY
INSTITUT TEKNOLOGI SEPULUH NOPEMBER SURABAYA
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VALIDATION SHEET

STUDY OF SOLID WASTE CONVERSION IN SURABAYA MUNICIPALITY

FINAL PROJECT REPORT

Proposed to fulfill the requirement to get Industrial Engineering Bachelor Degree
Industrial Engineering Department
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By :
RACHMASARI
NRP 2512 100 016

Approved by Supervisor :

Maria Anityasari, ST., M.E., Ph.D
NIP. 19701120 199703 2 001

KEMENTERIAN RISET, TEKNOLOGI, DAN PENDIDIKAN TINGGI
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ABSTRAK

PENELITIAN KONVERSI SAMPAH DI KOTA SURABAYA

Nama	: Rachmasari
NRP	: 2512100016
Pembimbing	: Dr. Maria Anityasari, S.T., M.E., Ph.D

Kota Surabaya merupakan salah satu kota besar di Indonesia yang sangat serius dalam implementasi *sustainable development.* Pemerintah Kota Surabaya memiliki tanggung jawab untuk mengatur pengangkutan sampah dari LPS (Lokasi Pembuangan Sementara) menuju TPA (Tempat Pembuangan Akhir) yang berlokasi di Benowo. Terdapat 37 LPS yang diangkut oleh truk sampah milik pihak swasta atau yang biasa disebut sebagai rekanan. Jumlah yang dibayarkan berdasar satuan volume dan jarak. DKP menganggap bahwa terdapat ketidakadilan ketika menggunakan satuan volume sebagai satuan unit pembayaran ke rekanan. Maka dari itu kebutuhan untuk merubah satuan pembayaran yang semula menggunakan volume menjadi satuan berat (tonase) sangat diperlukan.

Penelitian ini diawali dengan observasi dan *benchmarking* alternative yang memungkinkan untuk digunakan. Dari hasil *brainstorming* terdapat tiga alternative metode yang akan dikaji. Alternatif pertama adalah melakukan *sampling* perhitungan berat sampah di LPS untuk mengetahui penurunan berat sampah pada saat pengangkutan dari LPS ke TPA. Alternatif kedua adalah analisa manffat dan biaya penggunaan *segregated waste truck.* Alternatif ketiga adalah analisa statistik dengan metode *zoning* area LPS dan *sampling* densitas timbulan sampah.

Penentuan akhir metode yang akan digunakan adalah menggunakan metode *hybrid* antara alternatif metode 1 dan 3. Analisa statistik menggunakan teknik *zoning* are3a akan digunakan untuk mengetahui *range* densitas sampah di LPS dengan membagi LPS ke dalam kluster yang memiliki karakteristik sama dalam menghasilkan jumlah timbulan sampah. Untuk mengakomodasi teknik pada alternatif pertama, eksperimen dilakukan untuk mengetahui jumlah berat yang hilang pada saat pengangkutan dari LPS ke TPA. Kemudian faktor ini akan digunakan sebagai input untuk menentukan faktor konversi yang akan mempengaruhi jumlah timbulan sampah di LPS.

Key words : Municipal Solid Waste, Statistical Analysis, Mean Average Percentage Error (MAPE)

ABSTRACT

STUDY OF SOLID WASTE CONVERSION IN SURABAYA MUNICIPALITY

Name	: Rachmasari
NRP	: 2512100016
Supervisor	: Dr. Maria Anityasari, S.T., M.E., Ph.D

Surabaya is one of big cities in Indonesia that takes a serious action in implementing sustainable development. Government of Surabaya is responsible to manage solid waste transportation from LPS to TPA which located in Benowo. There are 37 LPS are being transported by dump trucks which owned by private companies or often referred as partners.The payment depend on volume and distance. DKP presumes that there is unfairness when implementing volume based for making payment to partners. Thus the need to convert payment from using volume based into becoming tonnage based is urgently required.

This research is started with observation and benchmarking of possible alternatives. From brainstorming process, three possible alternatives are generated. The first alternative is conducting sampling on selected LPS to figure out the reduction weight of solid waste being transported from LPS to TPA. The second proposed alternative is segregated waste truck which done by analyzing benefit and cost of the implementation. The third alternative is using statistical analysis by zoning LPS area and sampling the density of solid waste generation.

The final determination of method to use in this research is come up with hybrid method, between alternative 3 and 1. Statistical analysis using zoning method will be used to figure out the range of solid waste density in LPS by dividing the objected LPS into cluster which have similar characteristics in generating the amount of solid waste. In order to accommodate the method mentioned in alternative 1, another technique of experiment is generated to figure out the amount of weight loss occurred during the transportation from LPS to TPA. Then this factor will be used as the input to determine the conversion factor that will affect the amount of solid waste density in LPS.

The research result concludes that there are two option of determining solid waste density in LPS in Surabaya Municipality. The option is between to use single non specific density with value 303.07 kg/m^3 or to use varied specific density according to the density from each cluster. The use of single non specific density is practically simpler but lead to wide. deviation and the inaccuracy in estimating the actual value. Regarding the use of varied specific density from each cluster, it is less practically simple to use but more accurate and reduced the deviation. It is also enable to close the gap of payment that should be given to partners to DKP and make it more fair by using the accurate basis of conversion.

Key words : Municipal Solid Waste, Statistical Analysis, Mean Average Percentage Error (MAPE)

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CHAPTER VIII
CONCLUSION AND RECOMMENDATION

This chapter consists of conclusion from the research and objective achievements towards finding solution to the problems. This chapter also consists of recommendation from the research as basis of improvement in future research.

8.1 Conclusion

The conclusions from the research regarding solid waste conversion are as follow:

1. The factor that affect the conversion value from volume to weight of municipal solid waste collected in LPS is related to the amount of solid waste generation. The more solid waste generated in by the neighbors area of LPS, the higher the density of solid waste collected in LPS. Meanwhile the composition of solid waste generated in LPS is dominated with organic waste from residential area with small portion of non organic waste. This is due to sorting activity done by scavengers or garbage men who collect non organic waste to be sold again.
2. The method chosen in this research is determined based on the model that is constructed to estimate the density of solid waste in LPS. The required parameter to construct the model is to find the more accurate volume of solid waste collected in LPS container and to find the amount of weight loss during transportation process from LPS to TPA. Thus a sampling to measure the accurate volume of solid waste collected inside LPS container was conducted and an experiment to figure out the amount of weight loss along with the factors that affecting it was also conducted.
3. The selection of sampling location is done by dividing the object LPS into clusters based on the similarity of their characteristics in generating solid waste. The criteria to determine the characteristics LPS are defined and weighted using AHP and Expert Choice. Those criteria are population density in LPS neighbors area, economy level of LPS neighbors area, the ease of accessibility and the availability of solid

waste sources. The result of characteristics assessment show there are 8 clusters so that the chosen sampling location are 8 LPS.

4. The amount of weight loss is caused by the formation of leachate from the waste kept inside the container. The category of high amount of weight loss is likely found in the LPS that has wide served area which dominated with middle and high income residents. Combined with the availability of many nearby restaurant/café/hotel while the length duration of garbage being piled is long will causing the high amount of weight loss during transportation from LPS to TPA.
5. There are two option of determining density value of solid waste in LPS that well representing the solid waste generation in Surabaya Municipality. By neglecting the cluster of LPS characteristics in generating solid waste, it is obtained the single non specific value of 303.07 kg/m^3. Thus the other option is to have specific density value according to the cluster of LPS characteristics. The error measurement used to test both option in estimating the weight of solid waste shows that specific density value is more accurate and more appropriate to use as the conversion factor.
6. By applying the new solid waste density which vary according to each LPS clusters, the expenditure of solid waste transportation is evaluated and the result shows that the usage of volume as basis of payment is indeed causing unfairness.

8.2 Recommendation

The recommendation from the research as basis of improvement in future research is that the new solid waste density in LPS can be used as the basis to determine the new payment method of transportation activity done by partners. However with the growing of population and economy level of population in Surabaya, the density value requires periodical verification to ensure if it is still relevant or not to current condition of solid waste generation. The model constructed to estimate the density of solid waste in LPS can be used as the reference for the following research.

The density of solid waste in LPS can be the reference as well for the budgeting and determination of unit price to model the payment of solid waste transportation done by partners. Some aspects must be carefully considered such as the amount of budget, the forecast of solid waste generation, the range of uncertainty and the ownership management of the equipments and the vehicles in order to properly determine the new unit price.

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CHAPTER I
INTRODUCTION

This chapter consists of background of the research, problem identification, objectives and benefits that can be obtained through the research, limitation, assumption, and the writing systematic used.

1.1 Background

Surabaya is one of big cities in Indonesia that takes a serious action in implementing sustainable development. Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (International Institute for Sustainable Development, 2016). One of ways for environmental conservation in city development is through eco city. Eco city is a concept of green, healthy, and friendly attitude towards environment. This concept emphasized the physical relation between citizen and environment (Pemerintah Kota Bandung, 2013).

Various achievements have been obtained as the result of implementing eco city (Dinas Komunikasi dan Informasi Kota Surabaya, 2013), among them are Adipura Kencana for six consecutive years from 2006 to 2011, Adiwiyata for six schools in Surabaya, Kalpataru for NGO Tunas Alam as their attempt to preserve the environment, MURI for the construction of 13 parks which was formerly used as gas stations during 2008-2009, and Status Lingkungan Hidup Daerah (SLHD) in national level.

Integration among stakeholders, such as government, non government organization, media, private sectors and community, plays important role in the success of implementing eco city in Surabaya. Every component in city is encouraged to adapt with the concept, from residence, industry, public facility, school, hospital, etc. It requires huge amount of works for Surabaya Government to manage eco city. The challenge to face is regarding with high population density and high amount of municipal solid waste. Surabaya is one of big cities with high population density. It is recorded that the total population reaches up to

2.955.913 people in 2015 (Dinas Kependudukan dan Pencatatan Sipil Kota Surabaya, 2015).

Table 1. 1 Number of Population in Surabaya

Year	Number of Population in Surabaya
2013	3,200,454.00
2014	2,853,661.00
2015	2,995,913.00

Source: Dinas Kependudukan dan Catatan Sipil Kota Surabaya, 2015

Growth of population becomes one critical factor that affects the increase of municipal solid waste. Even though based on statistics population in Surabaya is decreasing in 2014 due to the closure of some prostitution locations which cause the move out of its residents, but the number of municipal solid waste keeps increasing. Another factor that affects the growth of its number is socio economic level, high economy level generally produces more solid waste (Damanhuri & Padmi, 2010). According to Surabaya Pagi online newsletter, Purchasing Power Parity (PPP) in Surabaya has increased becoming Rp 10.055,10 in 2015. It indicates that human development index has improved and people tend to have more power for consumption thus it will produce more solid waste in the city.

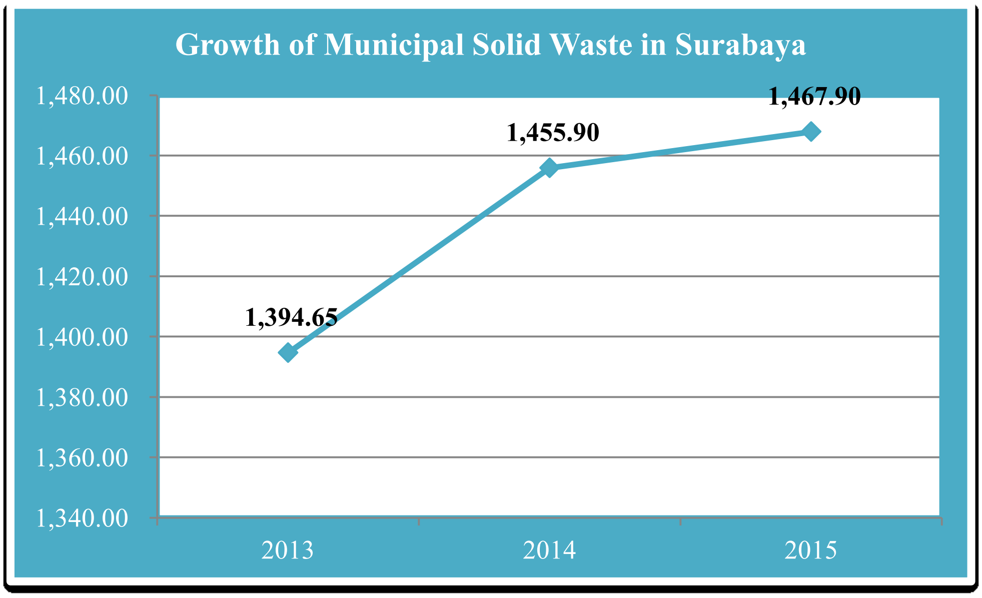

Figure 1. 1 Growth of Municipal Solid Waste in Surabaya (Source: Dinas Kebersihan dan Pertamanan Kota Surabaya, 2016)

Problems related to municipal solid waste are arising as the number keeps increasing. Solid waste that has been collected from residential and commercial places is often piled up in temporary solid waste disposal site before being transferred to landfill. This can lead to severe problems such as public health problems and cluttered urban design (Tchobanoglous, et al., 1993). The situation shows that increasing of municipal solid waste becomes challenges for the city to overcome. The Eco City concept is also implemented in municipal solid waste management to develop a sustainable solid waste management. It is defined as the discipline associated with the control of generation, storage, collection, transfer and transport, processing, and disposal of solid waste in a manner that is in accord with the best principles of public health, economics, engineering, conservation, aesthetics, and other environmental considerations (Tchobanoglous, et al., 1993). Figure 1.2 illustrates the operation of municipal solid waste management system implemented in Surabaya.

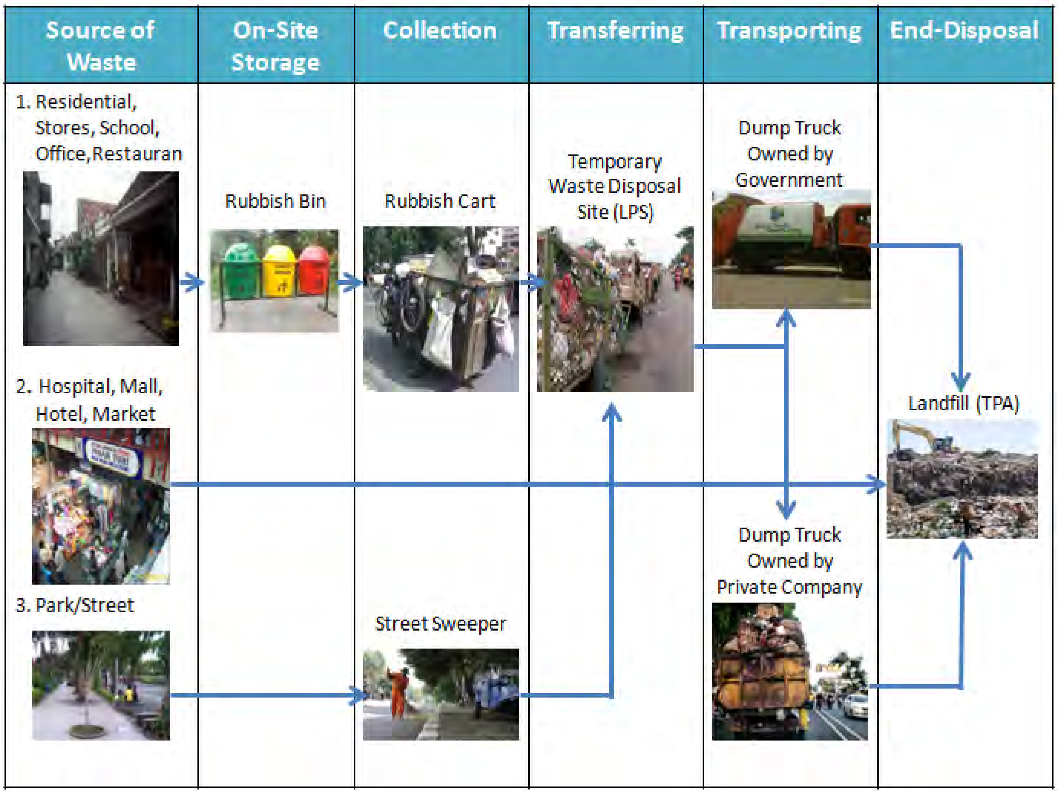

Figure 1. 2 Operational of Solid Waste Management in Surabaya (Source: Dinas Kebersihan dan Pertamanan, 2016)

The operation of solid waste management in Surabaya refers to SK SNI-T-12-1991-03 and SK SNI-T-13-1900-F which related to waste management procedures in residential and urban are (Pemerintah Kota Surabaya, 2014). There are four main activities which are waste storage, collection, transportation, and processing. Waste storage is the initial stage in which neighborhoods are responsible to provide trash bin or container to facilitate waste disposal. The disposed waste is collected and transferred to temporary solid waste disposal site (LPS), this activity is managed by RT and RW and generally use garbage cart. Solid waste in LPS needs to be transported to landfill (TPA) where the last stage, processing, is done in order to reduce the negative impact of dumped waste towards environment.

There are a total of 183 temporary solid waste disposal sites (LPS) in Surabaya and each LPS serves several nearby regions. Exceptional for solid waste coming from market, hotel, mall and hospital, the owners are required to transfer their solid waste directly to landfills by paying retribution cost to government.

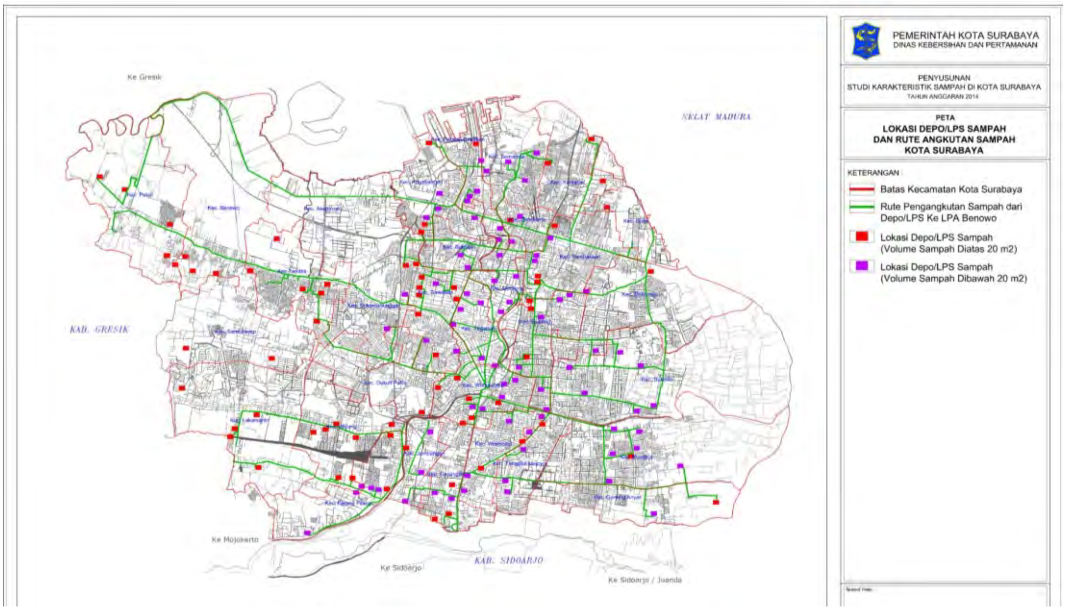

Figure 1. 3 Location of LPS in Surabaya (Dinas Kebersihan dan Pertamanan Kota Surabaya, 2014)

Government of Surabaya is responsible to manage solid waste transportation from LPS to TPA which located in Benowo. Dinas Kebersihan dan

Pertamanan (DKP) Kota Surabaya, the institution that is assigned to manage the task, are providing dump trucks to transport solid waste from LPS to TPA. From the existing 183 LPS, dump trucks owned by DKP are only able to transport solid waste from 146 LPS. While solid waste from other 37 LPS are being transported by dump trucks which owned by private companies or often referred as partners.

Based on Agreement Letter / Service and Procurement Contract which renewed every year, DKP partners are responsible to transport solid waste from particular LPS mentioned in the letter while DKP is responsible to provide payment for the service given. Solid waste that is transported to TPA are needed to be processed to control disposal solid waste accumulation and minimize the negative impact towards environment. Thus DKP is also responsible to make payment to TPA which is also owned by private sector. Figure 1.1 shows the picture of the system regarding to solid waste transportation management in Surabaya.

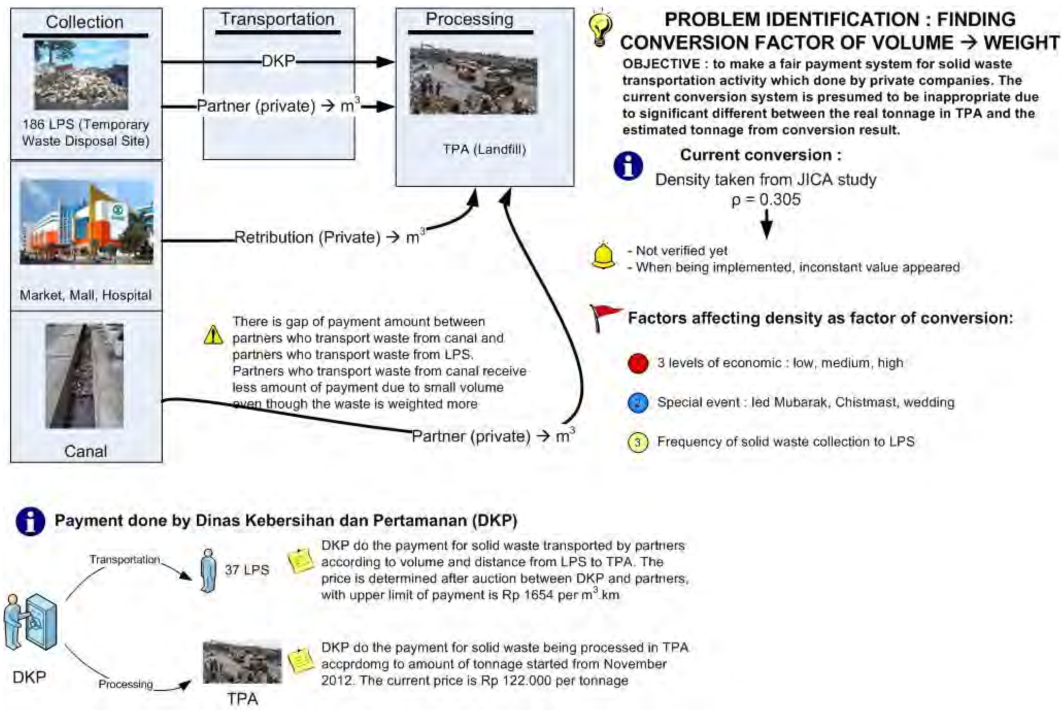

Figure 1. 4 System of solid waste transportation management in Surabaya (Drawn based on the information from Dinas Kebersihan dan Pertamanan Kota Surabaya, 2015)

According to Mid Term Regional Development Plan (RPJMD) Surabaya Municipality, the entire payment system to implement for DKP private partners is expected based on weight (tonnage). Previously DKP used volume as basis of payment both for transportation from LPS and processing activity in TPA. In 2013, the payment for solid waste processing in TPA has been converted into tonnage of solid waste weight by installing weighbridge to measure the weight of transported waste. However for the payment of solid waste transportation done by DKP partners from 37 LPS are still done based on volume.

In the Agreement Letter, written in Section 1 No. (2) about Work Scope – Solid Waste Transportation Work, the scope of work and basis of payment is managed under unit price contract. The unit price is based on volume (m^3) of solid waste volume being transported for every kilometer distance. Thus total amount of payment will be depend on volume and distance, the larger the volume and the further the distance, the more transportation cost charged to DKP. The contract also mentions that the payment will be given every month after partners completing the work based on Monthly Certificate (MC) reported to DKP. However there is no regulation stating a precise measurement of solid waste volume transported by partners.

Different unit is used to determine total expenditure for the two activities. It is expected that unit to determine transportation cost is converted into becoming tonnage of solid waste weight. DKP presumes that there is unfairness when implementing volume based for making payment to partners. As to illustrate the problem of volume based unit, two dump trucks loaded with same amount of solid waste volume does not always indicate same amount of weight. If the first dump truck contains of more paper, plastics, rubber, it is likely to have less weight than other dump truck contains of more food solid waste. In the other hand, dump trucks contain more of food solid waste is typically heavier yet having smaller volume due to compaction factor. But it is difficult for them to add more volume when the weight is reaching the limit even though there is still available space in container. Thus they get less amount of payment. Different with dump trucks contain more of paper, plastics, rubbers; they are typically less heavy yet tend to have bigger volume due to their physical dimension. They are at little risk of reaching the weight limit and able to keep loading until full capacity. This situation makes them getting more amount of payment.

DKP is very eager to make fair payment system for partner. Thus the need to convert payment from using volume based into becoming tonnage based is urgently required. The study to determine factors in converting volume into weight of solid waste is conducted in order to estimate the weight of municipal solid waste in 37 LPS. Several alternatives of methods are established to get the most appropriate method in field by analyzing benefits and constraints of each alternative. It is expected that the method enable to figure out the best weight estimation in order to develop a new mechanism to model the payment and to re-evaluate the budgeting expenditure for transporting activity done by partners.

1.2 Problem Identification

The identified problem to be solved in this study is to find conversion factor to convert volume unit into weight unit in order to make fair payment system to DKP partners in solid waste transportation activity. By having more accurate conversion, it is possible to re-evaluate budgeting expenditure for solid waste transportation.

1.3 Objectives

The objectives which will be achieved from this study are following:

1. To determine the factors that affects conversion value from volume to weight of municipal solid waste in Surabaya.
2. To identify and to analyze the most appropriate method among the method alternatives to estimate the weight of municipal solid waste.
3. To measure and to analyze the weight loss from municipal solid waste that is being transported from LPS to TPA.
4. To simulate the uncertainties that affect solid waste weight estimation in unit price system model.
5. To develop a new mechanism to model the payment and to evaluate the budgeting expenditure for transporting activity done by partners.

1.4 Scope

The scope of this study based on the limitation and the assumption used are following:

1.4.1 Limitation

Limitations that are used in this study are:

1. The object of the study is municipal solid waste collected in 37 temporary solid waste disposal site (LPS) which are divided into 4 regions.
2. The data of solid waste volume transported to landfill (TPA) by partners is taken from Dinas Kebersihan dan Pertamanan (DKP) Kota Surabaya which start from July 2014 until June 2015.
3. The source of municipal solid waste collected in LPS is excluding institution that produces solid waste > 2.5 m^3 per day.
4. The data of solid waste sources in 37 LPS which come from nearby RT/RW is taken from DKP Branch Administrative Office (Kantor Cabang Rayon DKP) of every region according to data entry in 2015.

1.4.2 Assumption

Assumptions that are used in this study are:

1. The measuring tape used to measure the volume of solid waste generation inside the dump container in LPS is accurate and valid.
2. The measuring glass used to measure the volume and weight of leachates drop from dump container in LPS is accurate and valid.
3. There is no significant change in demography data and spatial data of districts surrounded observed LPS during experiment.

1.5 Benefits

Some benefits which are going to be achieved through this study are following:

1. For Government

The result of this study can be used as a recommendation in establishing a new payment system of solid waste transportation from temporary waste disposal site (LPS) to landfill (TPA) which done by partner using weight/tonnage based unit.

2. For Student

The study enables student to gain some experiences and learning in understanding the structure of problems in real situation and implement the method to solve the problems using decision analysis concept.

1.6 Systematic

The writing systematic used in this report is as follow:

CHAPTER I INTRODUCTION

This chapter consists of introduction from the existing condition and the expected outcome of the study, then continued with identification of problems found in the existing system, objectives and benefits obtained by conducting the study, and scope of the study which consists of limitations and assumptions.

CHAPTER II LITERATURE REVIEW

This chapter consists of literature review used in conducting the study which becoming the theoretical basis for the writer in completing the study and finding solution for the problems. The theories used are written sequentially and interrelated between each subchapter in order to help directing completion of the study.

CHAPTER III RESEARCH METHODOLOGY

This chapter consists of explanation from the methodology used in completing the study and finding solution for the problems. The methodology is written sequentially in order to help directing completing of the study.

CHAPTER IV IDENTIFICATION OF METHOD ALTERNATIVES

This chapter consists of identification of method alternatives that can be used to find solution from the identified problems. Comprehensive analysis will be presented to support the argument in determining the most appropriate method. Any relevant data will be presented as well as the basis of the analysis.

CHAPTER V SELECTION OF SAMPLING LOCATION

This chapter consists of the sequence in determining sampling location to conduct the experiment. The sequence consists of selection criteria determination, LPS database formulation, weight calculation criteria, LPS characteristics assessment, and LPS clustering.

CHAPTER VI SAMPLING OF SOLID WASTE VOLUME MEASUREMENT AND EXPERIMENT OF SOLID WASTE LOSS FACTOR

This chapter consists of the experiment to find the more accurate measurement of solid waste volume inside dump container in LPS and to find the loss factor that affect the weight loss during the transportation of solid waste from LPS to TPA.

CHAPTER VII ANALYSIS OF SAMPLING AND EXPERIMENT RESULT AND EVALUATION OF EXPENDITURE FOR SOLID WASTE TRANSPORTATION

This chapter consists of the analysis from the result obtained in sampling of solid waste volume measurement and in experiment of weight loss during transportation from LPS to TPA. Evaluation of expenditure for solid waste transportation is also discussed by comparing the new conversion factor with the previous conversion factor used by DKP.

CHAPTER VIII CONCLUSION AND RECOMMENDATION

This chapter consists of conclusion from the research and objective achievements towards finding solution to the problems. This chapter also consists of recommendation from the research as basis of improvement in future research.

CHAPTER II
LITERATURE REVIEW

This chapter consists of literature review used during the study which explains about municipal solid waste, solid waste management system in Surabaya, and previous study in finding density and solid waste generation in Surabaya. Some references regarding alternatives of finding the conversion factors are also included in this chapter.

2.1 Municipal Solid Waste

Solid waste comprise all the wastes arising from human and animal activities that are normally solid and that are discarded as useless or unwanted. Municipal solid waste includes all the wastes generated from residential households and apartment buildings, commercial and business establishment, institutional facilities, construction and demolition activities, municipal services, and treatment plant sites (Tchobanoglous, et al., 1993). According to Indonesia Constitution Law UU 18-2008, solid waste is a solid form of excessive materials from human daily activities and/or natural processes.

Understanding solid waste is required in planning a municipal solid waste management system. Further explanation regarding municipal solid waste generation, composition, and characteristics in Surabaya are shown in the next subchapter.

2.1.1 Solid Waste Type and Source

Sources of solid wastes in a community are, in general, related to land use and zoning. Although any number of source classifications can be developed, the following categories are useful: (1) residential, (2) commercial, (3) institutional, (4) construction and demolition, (5) municipal services, (6) treatment plant sites, (7) industrial, and (8) agricultural. Typical waste generation of facilities, activities and locations associated with each of these sources are explained in table 2.1, where municipal solid waste (MSW) is normally assumed to include all community wastes with the exceptional of industrial process wastes and agricultural wastes (Tchobanoglous, et al., 1993).

Table 2. 1 Sources of solid wastes within a community

Sources	Typical facilities, activities, or locations where wastes are generated	Types of solid wastes
Residential	Single family and multifamily detached dwellings, low-, medium-, and high-rise apartments, etc.	Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, tin cards, aluminum, other metals, ashes, street leaves, special wastes (including bulky items, consumer electronics, white goods, yard wastes collected separately, batteries, oil, and tires), household hazardous wastes
Commercial	Stores, restaurants, markets, office buildings, hotels, motels, print shops, service stations, auto repair shops, etc.	Paper, cardboard, plastics, wood, food waste, glass, metals, special wastes (see above), hazardous wastes, etc.
Institutional	Schools, hospitals, prisons, governmental centers	As above in commercial
Construction and demolition	New construction sites, road repair/renovation sites, razing of buildings, broken pavement	Wood, steel, concrete, dirt, etc.
Municipal services (excluding treatment facilities)	Street cleaning, landscaping, catch basin cleaning, parks and beaches, other recreational areas	Special wastes, rubbish, street sweepings, landscape and tree trimmings, catch basin debris, general wastes from parks, beaches, and recreational areas
Treatment plant sites; municipal incinerators	Water, wastewater, and industrial treatment processes, etc.	Treatment plant wastes, principally composed of residual sludges
Municipal solid waste	All of the above	All of the above
Industrial	Construction, fabrication, light and heavy manufacturing, refineries, chemical plants, power plants, demolition, etc.	Industrial process wastes, scrap materials, etc. Non-industrial wastes including food wastes, rubbish, ashes, demolition and construction wastes, special wastes, hazardous wastes
Agricultural	Field and row crops, orchards, vineyards, dairies, feedlots, farms, etc.	Spoiled food wastes, agricultural wastes, rubbish, hazardous wastes

Sources : Tchobanoglous, et al., 1993

According to Dissemination of Public Works I – Waste Management, the sources and the types of solid waste are divided into four categories:

a. Residential
   - High income residents
   - Middle income residents
   - Low income residents / slum area
b. Commercial
   Market, stores, hotel, restaurants, cinema, aesthetic clinics, industry, etc.
c. Public Facilities
   Offices, schools, hospitals, drugstores, sport centre, museum, park, street, canal
d. Social Facilities
   Social institutions, mosques, churches, temples

2.1.2 Solid Waste Generation

Weight of solid waste is strongly affected by season, especially for a developing and tropical country like Indonesia. Season in this term can be interpreted as rainy and dry season, as well as fruits season. On the other side, weight of solid waste is also affected by other social and cultural factors (Damanhuri & Padmi, 2010). Thus the evaluation on solid waste generation should be done in several times in a year. Solid waste generation can be obtained with sampling (estimation) based on standard. This generation is stated as:

- Weight unit : kg/person/day, kg/m^2/day, kg/bed/day, etc.
- Volume unit : L/person/day, L/m^2/day, L/bed/day, etc.

Indonesia generally implements volume unit. The implementation of volume system may lead to misinterpretation due to compaction factor that needs to be included. As an illustration, 10 unit containers consist of 100 liter water, if the water from each container is put all together in one big container, then it will consist 1000 liter water. Otherwise 10 unit containers consist of 100 liter solid waste, if the solid wastes are put all together; there is a tendency that the volume will be reduced due to compaction. While the solid waste weight is remain the same. This compaction factor is known as density.

Average of solid waste generation usually varies from day to day, between one region to other region, and between one country to another country. This variation is mainly caused by differences of:

- Number of population and rate of population growth
- Season: for countries in west, solid waste generation reaches to minimum level during summer
- Lifestyle and mobility of citizens
- Climate: for countries in west, ashes from burning heater is increased during winter
- Weather: waste moisture is higher for a place with high water composition
- Collection frequency: the more frequent in collecting solid waste, the higher accumulation of solid waste. But organic waste will be decreased due to decaying, while inorganic waste will be increased due to its difficulty in degradation
- Socio economy level: high economy level generally produces more inorganic waste such as tin, paper, plastic, etc.
- Income per capita: low income or low economy area tends to produce less total of solid waste yet more homogeny than high income area
- Product packaging: developed countries use more of papers as packaging material, while developing countries like Indonesia use more plastics as packaging material

Solid waste generation is varied according to sources of the waste, as shown in Table 2.2.

Table 2. 2 Solid waste generation according to source components

No.	Source Components	Unit	Volume (liter)	Weight (kg)
1.	Permanent house	/person/day	2.25 – 2.50	0.350 – 0.4.00
2.	Semi permanent house	/person/day	2.00 – 2.25	0.300 – 0.350
3.	Non-permanent house	/person/day	1.75 – 2.00	0.250 – 0.300
4.	Office	/employee/day	0.50 – 0.75	0.025 – 0.100
5.	Store	/student/day	2.50 – 3.00	0.150 – 0.350
6.	School	/m/day	0.10 – 0.15	0.010 – 0.020
7.	Secondary arterial street	/m/day	0.10 – 0.15	0.020 – 0.100
8.	Secondary collect street	/m/day	0.10 – 0.15	0.010 – 0.050

Table 2. 3 Solid waste generation according to source components (Cont`d)

No.	Source Components	Unit	Volume (liter)	Weight (kg)
9.	Local street	/m/day	0.05 – 0.10	0.005 – 0.025
10.	Market	$/m^2/day$	0.20 – 0.60	0.100 – 0.300

Source: Damanhuri & Padmi, 2010

Some studies show that solid waste generation in Indonesia is ranged from 2-3 liter/person/day with density 200-300 kg/m^3 and organic composition is 70-80% (Damanhuri & Padmi, 2010).

According to SNI 19-3964-1995, if direct observation is not available, the method to calculate solid waste generation is using:

- Solid waste generation for big city = 2 – 2.5 L/person/day, or = 0.4 – 0.5 kg/person/day
- Solid waste generation for small city = 1.5 – 2 L/person/day, or = 0.3 – 0.4 kg/person/day

Because municipal solid waste generation mostly come from residential areas, then number of solid waste generated from residential is presumes to be representing other sources. Meanwhile for bigger city, like Jakarta and Surabaya, portion of solid waste from residential areas is decreasing, while portion from non-residential areas is increasing.

2.1.3 Solid Waste Composition

The next categorizing of solid waste is in accordance with its composition, expressed as %weight or %volume from paper, wood, leather, rubber, plastic, metal, glass, fabric, food, etc. Table 2.3 shows typical of municipal solid waste composition in developed countries.

Table 2. 4 Composition of domestic solid waste

Category	%Weight	%Volume
Paper and paper materials	32.98	62.61
Wood or wooden products	0.38	0.15
Plastic, leather, and rubber	6.84	9.06
Fabric and textile products	6.36	5.1
Glass	16.06	5.31

Category	%Weight	%Volume
Metal	10.74	9.12
Rock or sand	0.26	0.07
Organic waste	26.38	8.58

Source: Damanhuri & Padmi, 2010

Organic waste refers to components that quickly degraded or decompose, mainly from excessive of food. Decomposed solid waste is the waste that quickly decomposed due to microorganism activities (Damanhuri & Padmi, 2010). Thus it requires rapidity in each waste management process starting from collection, disposal as well transportation. Decaying of organic waste causes smelly odor, like ammoniac, volatile acid, and methane gas which damaging for people health. Accumulation of decayed organic waste must be avoided.

Non decayed waste generally consists of paper, metal, plastic, glass, and other non organic waste. Dry waste (refuse) or inorganic solid waste is preferred to be recycled; else it will require to be processed, for example by burning it. But this process requires careful operation since it has potential to pollute the air, especially if the processed waste contains PVC plastics.

For cold climate countries, ashes and dusts are produced a lot as a result of combustion, whether fuel combustion for room heater or waste combustion from incinerator. Dust in tropical countries like Indonesia, mainly from street sweeping. As long as it does not contain dangerous material, dust is not highly damaging for environment and society. However, <10 µm dust can enter respiration channel in human body and cause pneumoconiosis.

Hazardous waste is the type of waste that contains harmful material for human, flora and fauna. Hazardous waste generally consists of organic and inorganic chemical and heavy metal, which mostly excess from industry. This type of waste is required to be managed by the authorized institution and released to environment according to health and safety standard. It must not be mixed with other municipal solid waste.

For the purpose of comparison, typical data on the distribution of the components in residential MSW from other countries are presented in table 2.4. Note that the percentage of food waste is high in less-developed countries because most vegetables and fruits are not pre-trimmed, there are essentially no kitchen food waste grinders, and the amounts of the other components are quite small (Tchobanoglous, et al., 1993).

Table 2. 5 Typical distribution of components in residential MSW for low-, middle-, upper-income countries excluding recycled materials

Component	Low-income countries	Middle-income countries	Upper-income countries
Organic			
Food wastes	40-85	20-65	6-30
Paper	1-10	8-30	20-45
Cardboard			5-15
Platics	1-5	2-6	2-8
Textiles	1-5	2-10	2-6
Rubber	1-5	1-4	0-2
Leather			0-2
Yard wastes	1-5	1-10	10-20
Wood			1-4
Misc. organics	-	-	-
Inorganic			
Glass	1-10	1-10	4-12
Tin cans			2-8
Aluminum	1-5	1-5	0-1
Other metal			1-4
Dirt, ash, etc.	1-40	1-30	0-10

Sources : Tchobanoglous, et al., 1993

Variation in the Percentage Distribution of Waste Components

The percentage distribution values for the components in MSW vary with location, season, economic condition, and many other factors. Typical seasonal variation in waste quantities is presented in table 2.5. Because variations are known to occur, if distribution of components is a critical factor in a particular management decision process, a special study should be undertaken if possible in assess the actual distribution (Tchobanoglous, et al., 1993). Even then, it may still be impossible to obtain an accurate assessment unless a prohibitively large number of sample are analyzed. In general, the coefficient of variation (CV) for individual waste constituent is quite large. Typical CV values for paper in residential MSW range from about 20 to 40 percent. For the remaining components in the waste stream, CV value can vary from 40 to 100 percent.

Table 2. 6 Typical seasonal variation observed in the as collected composition of residential MSW

Waste	Percent by Weight		Percent by Variation	
	Winter Season	Summer Season	Decreased	Increased
Food waste	11.1	13.5		21.6
Paper	45.2	40.0	11.5	
Plastic	9.1	8.2	9.9	
Other organic	4.0	4.6		15.0
Yard waste	18.7	24.0		28.3
Glass	3.5	2.5	28.6	
Metal	4.1	3.1	24.4	
Inert and other metal	4.3	4.1	4.7	
Total	100	100		

Sources : Tchobanoglous, et al., 1993

A common failing in many engineering studies is to spend far too much money collecting data that are of limited value or may never be used. This situation is often true with regard to the collection during one sampling period. For example, it is usually more important to have information on the seasonal variation of waste generation rates than to know whether the percentage of a given component during any one sampling period.

2.1.4 Solid Waste Characteristics

Characteristic of solid waste can be divided into physic and chemical characteristics. Characteristic variation depends on the composition and the source area or region which leads to different characteristics (Damanhuri & Padmi, 2010).

- Physic characteristics: density, moisture, volatile content, ashes content, heat level, and size distribution
- Chemical characteristics: represents chemical composition of solid waste which generally contains of C, N, O, P, H, S, etc.

According to observation in the field, density is affected by facilities used in collection and transportation process, normally for designing the facilities, particular range is used:

- Solid waste in home garbage bin: 0.01 – 0.20 ton/m^3
- Solid waste in garbage cart: 0.20 – 0.25 ton/m^3
- Solid waste in dump truck: 0.30 – 0.40 ton/m^3
- Solid waste in landfill with conventional operation: 0.50 – 0.60 ton/m^3

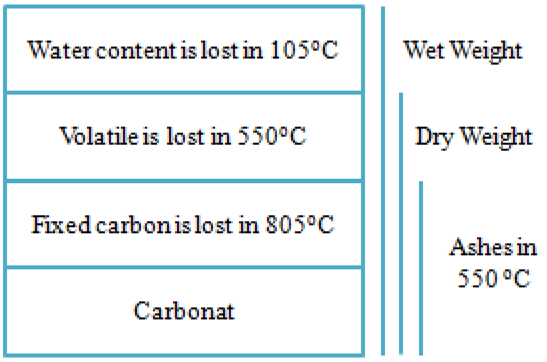

Figure 2. 1 Substance position in particular combustion temperature (Source: Damanhuri & Padmi, 2010)

a. Density

   Density refers to weight of solid waste per unit volume. Low solid waste density causes the increasing of disposal area used in landfill and the decreasing of land surface.

b. Moisture

   Understanding moisture of solid waste in particular area is used to determine collection frequency. It is also depend on the solid waste composition.

c. Volatile Content

   Understanding volatile content is used to estimate solid waste reduction effectiveness during combustion or annihilation process.

d. Ashes Content

   Ashes content refers to excessive solid waste material after being combusted in high temperature. It is used to determine combustion effectiveness.

e. Energy or Heat Content

Understanding energy content is essential in thermal solid waste processing which using heat energy as the source (combustion process). Heat content is the total amount of heat released after one unit mass of solid waste has been completely combusted.

2.1.5 Solid Waste Specific Weight and Moisture Content

Specific weight is defined as the weight of a material per unit volume (e.g., lb/ft^3, lb/yd^3). (It should be noted that specific weight expressed as lb/yd^3 is commonly referred to in the solid waste literature incorrectly as density. In U.S., customary units' density is expressed correctly as $slug/ft^3$). Because the specific weight of MSW is reported as loose, as found in containers, uncompacted, compacted, and the like, the basis used for the reported values should always be noted. Specific weight data are often needed to assess the total mass and volume of waste that must be managed (Tchobanoglous, et al., 1993). Unfortunately, there is little or no uniformity in the way solid waste specific weights have been reported in the literature. Frequently, no distinction has been made between uncompacted or compacted specific weights. Typical specific weight for various wastes as found in containers, compacted, or uncompacted are reported in table 2.6.

Table 2. 7 Typical specific weight and moisture content data for residential and municipal wastes

Type of waste	Specific weight, kg/m^3		Moisture content, % by weight	
	Range	Typical	Range	Typical
Residential (uncompacted)				
Food wastes (mixed)	131 – 481	291	50 – 80	70
Paper	42 – 131	89	4 – 10	6
Cardboard	42 – 80	50	4 – 8	5
Plastics	42 – 131	65	1 – 4	2
Textiles	42 – 101	65	6 – 15	10
Rubber	101 – 202	131	1 – 4	2
Leather	101 – 261	160	8 – 12	10
Yard wastes	59 – 225	101	30 – 80	60
Wood	131 – 320	237	15 – 40	20
Glass	160 – 481	196	1 – 4	2

Table 2. 8 Typical specific weight and moisture content data for residential and municipal wastes (Cont`d)

Type of waste	Specific weight, kg/m^3		Moisture content, % by weight	
	Range	**Typical**	**Range**	**Typical**
Tin cans	50 – 160	89	2 – 4	3
Aluminum	65 – 240	160	2 – 4	2
Other metals	131 – 1151	320	2 – 4	3
Dirt, ashes, etc.	320 – 1000	481	6 – 12	8
Ashes	650 – 831	745	6 – 12	6
Rubbish	89 – 181	131	5 – 20	15
Municipal				
In compactor truck	178 – 451	297	15 – 40	20
In landfill				
Normally compacted	362 – 498	451	15 – 40	25
Well compacted	590 - 742	599	15 - 40	25

Sources : Tchobanoglous, et al., 1993

Because the specific weight of solid wastes very markedly with geographic location, season of the year, and length of time in storage, great care should be used in selecting typical values. Municipal solid wastes as delivered in compaction vehicles have been found to vary from 300 to 700 lb/yd^3, a typical value is about 500 lb/yd^3. Note that lb/yd^3 x 0.5933 = kg/m^3.

The moisture content of solid wastes usually is expressed in one of two ways. In the wet-weight method of measurement, the moisture in a sample is expressed as a percentage of the wet weight of the material in the dry-weight method, it is expressed as a percentage of the dry weight of the material. The wet-weight method is used most commonly in the field of solid waste management. In equation form, the wet-weight moisture content is expressed in equation 2.1:

$$M = \left(\frac{w-d}{w}\right) \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots (2.1)$$

Where M = moisture content, %

w = initial weight of sample as delivered, lb (kg)

d = weight of sample after drying at 105°C, lb (kg)

For most MSW in the United States, the moisture content vary from 15 to 40 percent, depending on the composition of the waste, the season of the year, and the humidity and weather conditions, particularly rain.

2.2 Municipal Solid Waste Management

Solid waste management may be defined as the discipline associated with the control of generation, storage, collection, transfer and transport, processing, and disposal of solid waste in a manner that is in accord with the best principles of public health, economics, engineering, conservation, aesthetics, and other environmental considerations. Inefficient and improper methods of disposal of solid waste result in scenic blights, create serious hazards to public health, including pollution of air and water resources, accident hazards, and increase in rodent and insect vectors of disease, have an adverse effect on land values, create public nuisances, otherwise interfere with community life and development. The failure or inability to salvage and reuse such materials economically results in the unnecessary waste and depletion of natural resources (Tchobanoglous, et al., 1993).

Government plays important roles in setting up a proper municipal solid waste management. Dinas Kebersihan dan Pertamanan (DKP) Kota Surabaya becomes the institution that responsible to manage municipal solid waste from sources until end-disposal land. Managing municipal solid waste becomes more complex with increasing growth of population. By 2015, total population in Surabaya reaches up to 2.955.913 people with average growth rate 0,63% (Dinas Kependudukan dan Pencatatan Sipil Kota Surabaya, 2015). Growth of population causes the increase of municipal solid waste volume.

This subchapter explains the operation of municipal solid waste system implemented in Surabaya and the consequences in government expenditure. However since the study focuses only in transportation operation which done by private companies, thus comprehensive information presented will be covering solid waste transportation system only.

2.2.1 Operation of Municipal Solid Waste Management System in Surabaya

Previous study written by Sarwoko Mangkoedihardjo with title "Quality Improvement in City Environment: Sustainable Municipal Solid Waste Management" explaining the implementation of solid waste management in Surabaya. In his study, it is stated that the general system encompasses entire areas in the city with centralistic end-disposal system. There are five categories of disposal facilities for mix or unsegregated solid waste. First facility is garbage bin owned and managed by community. Second facility is solid waste collection from community garbage bin to be transferred to temporary solid waste disposal site (LPS). Garbage cart is used to facilitate this process. With number of garbage cart serves each sub district (RW) is 1 – 2 units. Third facility is LPS that is managed by DKP. LPS is an open area with average of total space required is 250 m^2. This space is divided into disposal operational space (150 m^2) and parking base space for incoming and outgoing facilities (100m^2). Forth facility is solid waste transportation from LPS to landfill (TPA). Dump truck is used to do the task and each dump truck generally serves 2 LPS, or in average 120 m^3/day of transported solid waste. Fifth facility is TPA that is managed by DKP. Disposal method implemented in this end-disposal site is open dumping.

2.2.2 Municipal Solid Waste Transportation System in Surabaya

Solid waste transportation system in Surabaya is divided into two categories. First is collection from sources to temporary waste disposal site (LPS) which done using rubbish cart. DKP provides 1-2 garbage cart for each sub district (RW). Second is transporting from LPS to landfill (TPA) which done using dump truck. DKP provides variety of dump truck to perform this operation which can be categorized as compactor dump truck, hydraulic container / arm roll dump truck, tank and water tank truck, sky walker truck, pick up, station wagon, jeep taft, excavator, etc.

From 186 existing LPS in Surabaya, DKP is only able to accommodate dump truck for 149 LPS. While the other 37 LPS is being served with dump truck owned by private companies. These private companies are engaged in contract with DKP and they are paid for transporting solid waste from LPS to TPA. 37 LPS is divided into four regions, north, central, south, and east, list of each LPS is:

Table 2. 9 List of LPS Served by Private Company

No.	Central	South	East	North
1	LPS Legundi	LPS Waru Gunung	LPS Kangean	LPS Krembangan Barat
2	LPS Penghela	LPS Karang Pilang	LPS Bratang	LPS Indrapura
3	LPS Kayun	LPS Kebraon	LPS Rungkut Menanggal	LPS Babaan
4	LPS Tambak Rejo	LPS Kemlaten	LPS Gebang Putih	LPS Benteng
5	LPS Simo Lawang	LPS Bogangin	LPS Klampis Ngasem	LPS Wonokusumo
6	LPS Dinoyo	LPS Kembang Kuning	LPS Kutisari Indah	LPS Dupak Bangunsari
7	LPS Pasar Kembang	LPS Babadan Indah	LPS Kendang Sari	LPS Ampel
8	LPS Kedung Anyar	LPS Joyoboyo	LPS Tenggilis Mejoyo	
9	LPS Kedondong	LPS Bendul Merisi	LPS Semolowaru	
10	LPS Legundi		LPS Rungkut Alang-alang	
11			LPS Penjaringan Sari	

Source: Dinas Kebersihan dan Pertamanan, 2016

2.2.3 Payment Regulation for Solid Waste Transportation done by Partners

Partnership between Dinas Kebersihan dan Pertamanan (DKP) Kota Surabaya and private companies is regulated under Agreement Letter/Service Provider Contract for Solid Waste Transportation in Surabaya. There are four partners working with DKP to manage solid waste transportation from LPS to TPA which located in Benowo. The contract for each partner is regulated under different agreement letter, adjusted to auction result. However each agreement letter mostly covering same matters and procedure except for unit price for every

m^3 and km of solid waste being transported. The unit price is determined from auction proceeds between DKP and partners.

The agreement letter is made and signed in the beginning of the year. It informs all procedures that must be obeyed and executed by both parties. Unit price contract is highlighted in the first page which states that completion of the work must be done within the set time limits. It also regulates volume of solid waste which determines according to estimation, means that there is no precise measurement to determine the volume. Estimation is done by dividing the actual weight from weighbridge in TPA with density factor 0.305 ton/m^3. Density factor used since beginning of 2015 is taken from previous study done by JICA (Japan International Cooperation Agency). However in the practice, the estimation needs to be adjusted with the real physical volume collected in truck container by accumulating solid waste volume in each garbage cart. Thus DKP presumes that volume unit is not a proper base of payment because there is high tendency of unfairness in the system and may lead to misinterpretation due to compaction factor that not yet included.

The agreement letter also mentions regarding to budget plan made for one year of contract between DKP and partners. DKP makes budgeting based on the historical volume being transported from every LPS. Payment to partner is done every month according to Monthly Certificate (MC) which consist of solid waste volume being transported within one month.

Other contents in the agreement letter is covering standard of condition that must be obeyed by partner. For instance regarding labor, partners must provide minimum three labors for each dump truck. They are also responsible to provide safety equipment for their labors according to standard, which consists of long t-shirt, masker, ranger hat, and boots. Working equipment must be provided as well, which consists of scratch + handles, baskets, shovel, tarpaulins/closing tailgate, garbage net.

According to procedure mentions in the agreement letter, transportation of solid waste from LPS to TPA is expected to be done before 8 am. Dump truck must be ensured to have coverage to avoid spilled waste on road. Once dump truck arrives in TPA, it must be passed weighbridge in order to obtain actual weight of solid waste in TPA. This actual weight will be used as the report to DKP and will be converted into volume unit to determine total amount of payment.

2.3 Previous Study

The factor involved in converting volume into tonnage is density. Previous study using density 0.305 tonnage/m^3 is tried to be implemented to get the most proper weight estimation. This value of density is obtained from previous study done by JICA. However there is no written proof that can be found in DKP database regarding this study. When this density is applied in the conversion system, the weight estimation is showing inconstant value as shown in Figure 1.2.

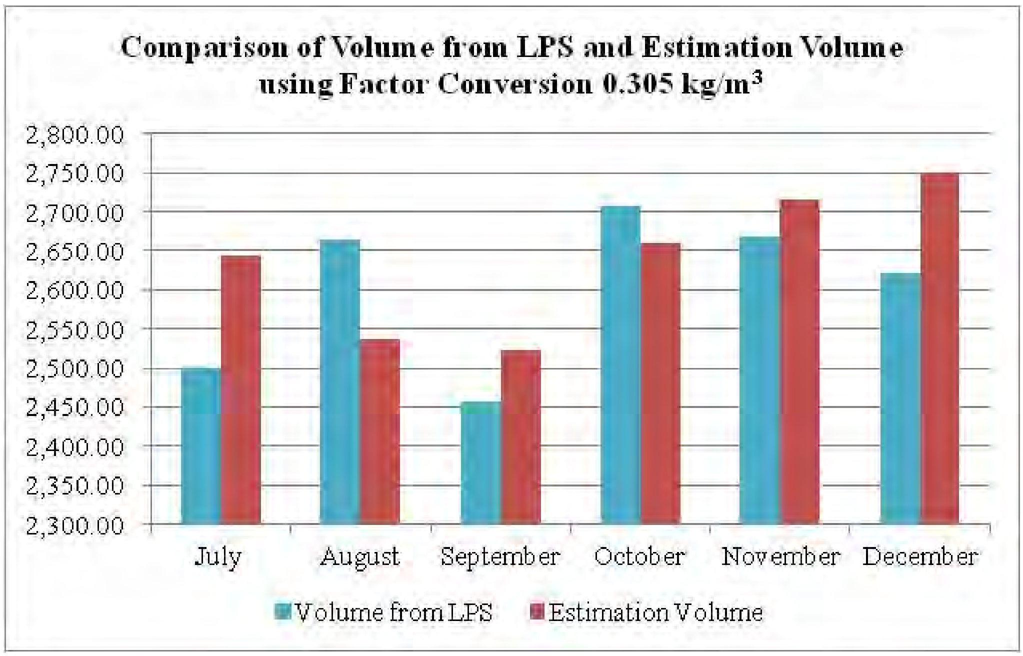

Figure 2. 2 Comparison of volume from LPS Kembang Kuning and estimation volume using factor conversion 0.305 kg/m^3

Another reference regarding factor conversion density is taken from Tchobanoglous in his book "Integrated Solid Waste Management". In this book, it is stated that the municipal solid wastes as delivered in compaction vehicles have been found to vary from 300 to 700 lb/yd^3, a typical value is about 500 lb/yd^3 or equal to 297 kg/m^3. However the character of solid waste in LPS is actually in non compacted state, thus the moisture content needs to be concerned. As it is noted in the book that typical moisture content in municipal solid waste is 20% of its density, thus it is obtained that typical density in LPS is 355.8 kg/m^3.

Previous study regarding generation rate of municipal solid waste in Surabaya also has been conducted in 2014 by a team of consultant whom partnered with DKP. The study aimed to figure out characteristics and rate of solid waste generated from different sources. The purpose for government itself is as a basis for planning proper municipal solid waste management in the future. Sampling was used as the method to conduct the study based on standard of procedure written in SNI 19-3964-1994 regarding Sampling and Measurement Method of Municipal Solid Waste Generation Rate and Composition. Ten sub districts (kecamatan) was selected as the sampling location. Sampling was conducted by measuring volume and weight of solid waste from different sources, which divided into residential, apartment, market, hospital, public transportation transit, shopping centre, industry and warehouse, and open space area. Data of area mapping from each sub district was collected in order to determine selected sources as a place to conduct the sampling.

Measurement to figure out solid waste generation rate was conducted after collecting data from sampling. Further analysis was done in laboratory in order to figure out physical, biological and chemical characteristics of the solid waste. By acknowledging volume and weight of solid waste produced from each source, the researchers were also able to determine density of solid waste generated in order to figure out composition of solid waste in each sub district.

Solid waste composition is changing from time to time and becoming more complex. According to data of solid waste composition in Surabaya from 1988 to 2010, organic waste is decreasing while inorganic waste mainly packaging waste is increasing.

Table 2. 10 Solid waste composition in Surabaya

No	Composition	Weight Percentage (%)		
		1988*	2006**	2010***
1	Organic Solid Waste	77,30	72,40	68,50
2	Paper	6,20	7,30	6,10

No	Composition	Weight Percentage (%)		
		1988*	2006**	2010***
3	Plastic	5,60	10,10	12,40
4	Wood	4,60	2,40	2,30
5	Metal	1,00	1,40	1,00
6	Glass	0,40	1,70	1,40
7	Leather	0,80	0,50	0,50
8	Fabric	2,20	2,70	4,00
9	Others	4,60	1,50	3,80
Jumlah		**100,00**	**100,00**	**100,00**

Source : Arsitektur Spasial Nusa, 2014

From table 2.8, it is shown that there is decreasing percentage of organic waste and increasing percentage of plastic waste. For other components such as paper, metal, and glass waste, the percentage tends to be unchanged. However organic waste still dominates most proportion percentage.The increasing percentage of plastic waste brings up problems since its volume takes 25% to 35% out of the total volume. The consequence is if the percentage keeps increasing, land area required in landfill is increasing as well.

Table 2.9 and table 2.10 shows the result of the study which presenting the percentage of solid waste composition and solid waste generation from several sources in Surabaya.

Table 2. 11 Percentage of solid waste composition in Surabaya

No	Solid Waste Composition	Percentage (%)
1	Organic Waste	54,31%
2	Wood / Wood product	1,61%
3	Leather	1,19%
4	Rubber	1,14%
5	Plastic	19,44%
6	Paper	14,63%
7	Textile	1,47%
8	Glass	1,12%
9	Ceramic	0,17%
10	Metal	0,48%
11	B3	0,86%
12	Others	3,59%
Total		**100,00%**

Source: Arsitektur Spasial Nusa, 2014

Table 2. 12 Solid Waste Generation in Surabaya

No	Sampling Object	Average		
		Volume	Weight	Density
		($L/m^2/hr$)	($Kg/m^2/hr$)	($Kg/m^3/hr$)
1	Market	1,71	0,19	210,42
2	Street	0,62	0,016	234,88
3	Park/Open Space	0,12	0,019	160,15
4	Office	6,06	0,144	230,83
5	Stores	0,05	0,013	305,37
6	PKL Central	0,56	0,022	371,58
7	Water Gate	141,41	62,763	469,03
8	Residential	3,22	0,704	288,00
9	Railway Station	2,19	0,496	265,21
10	Bus Station	0,41	0,996	209,86
11	Medical Centre	2,45	0,361	148,95
12	Apartment	0,47	0,072	302,70
13	School	0,14	0,019	91,108
14	Hotel	1,92	0,233	126,69
15	Worship Site	0,03	0,009	87,216
16	Mall	0,06	0,007	152,85
17	Restaurant	0,22	0,476	193,06
18	Home Industry	776,69	0,067	504,00
19	Industry	3,10	0,833	277,68

Source : Arsitektur Spasial Nusa, 2014

2.4 Statistical References for Statistical Analysis

This subchapter consists of literature review on the tools and method used to analyze the method alternatives. The method to evaluate density from previous study is presented is presented as well.

2.4.1 Linear Regression and Correlation

Linear regression and correlation analysis are two of the most often applied statistical procedures used by business decision makers for analyzing the relationship between two variables (Groebner, 2011). These methods are used in this study to analyze the relationship between variables volume and weight of solid waste in order to well understanding conversion factor between them. Decision making situations that call for understanding the relationship are aided by the use of scatter plots, or scatter diagrams. It is a two dimensional plot showing the values for the joint occurrence of two quantitative variables. A dependent (or response) variable is the variable whose variation is going to be explained. And independent (or explanatory) variable is a variable used to explain variation in the dependent variable.

In addition to analyze the relationship between two variables graphically, the strength of linear relationship between two variables is measured using correlation coefficient. The correlation coefficient of two variables can be estimated from sample data using equation 2.2.

$$r = \frac{\Sigma\,(x-\bar{x})(y-\bar{y})}{\sqrt{[\Sigma\,(x-\bar{x})^2(y-\bar{y})^2]}} \ldots\ldots\ldots\ldots\ldots (2.2)$$

The sample correlation coefficient, r, can range from a perfect positive correlation, +1.0, to a perfect negative correlation, -1.0. A perfect correlation is one in which all points on the scatter plot fall on a straight line. If two variables have no linear relationship, the correlation between them is 0 and there is no linear relationship between the change in x and y. Consequently, the more the correlation differs from 0.0, the stronger the linear relationship between the two variables.

Simple linear regression is the method of regression analysis in which a single independent variable is used to predict the dependent variable (Groebner, 2011). The objective of simple linear regression is to represent the relationship between values of x and y with a model of the form shown in equation 2.3

$$y = \beta_0 + \beta_1 x + \varepsilon \ldots\ldots\ldots\ldots\ldots (2.3)$$

Where:

y = value of dependent variable

x = value of independent variable

β_0 = population`s y intercept

β_1 = slope of population regression line

ε = random error term

The simple linear regression population model described in equation 2.3 has four assumptions. Individual values of the error terms, , are statistically independent of one another, and these values represent a random sample from the population of possible ε - values at each level of x. For a given value of x, there can exist many values of y and therefore many values of ε. The distribution of possible ε values have equal variances for all values of x. the means of the dependent variable, y, for all specified values of the independent variable, ($\mu_{y\backslash x}$), can be connected by a straight line called the population regression model.

The population regression line is determined by two values, β_0 and β_1, known as regression coefficients. The populations intercept, β_0, indicates the mean value of y when x is 0. However, this interpretation holds only if the population could have x value equal to 0. When this cannot occur, β_0 does not have a meaningful interpretation in the regression model. Coefficient β_1, the regression slope coefficient, measures the average change in the value of the dependent variable, y, for each unit change in x.

2.4.2 Comparing Estimated Values with Actual Data

Computing the forecast or estimated error by comparing the trend line values with actual past data is an important part of the model diagnosis step. The errors measure how closely the model fits the actual data at each point (Groebner, 2011). This computation is useful in evaluating the most appropriate density used as conversion factor among the varied density found from previous study. Two commonly used measures of fit are mean squared residual, or mean squared error (MSE), and mean absolute deviation (MAD). These measures are computed using equation 2.4 and 2.5, respectively. MAD measures the average magnitude of the forecast errors. MSE is a measure of the variability in the forecast errors. Another commonly measurement used is mean absolute percentage error (MAPE). MAPE measures the precise of estimated values which represents in percentage of absolute error average.

$$MSE = \frac{\Sigma\,(y_{t-}\,F_t\,)^2}{n} \ldots\ldots\ldots\ldots\ldots..(2.4)$$

$$MAD = \frac{\Sigma|y_{t-}\,F_t\,|}{n} \ldots\ldots\ldots\ldots\ldots...(2.5)$$

$$MAPE = \frac{\Sigma|y_{t-}\,F_t\,|/y_t}{n} \text{x } 100\ldots... (2.6)$$

Where:

y_t = actual value at time t

F_t = predicted or estimated value at time t

n = number of time period

These error measures are particularly helpful when comparing two or more forecasting techniques. MSE, MAD and MAPE can be computed for each forecasting or estimated values. The values that gives smallest MSE, MAD or MAPE is generally considered to provide the best fit.

2.5 References for Solid Waste Volume Measurement and Solid Waste Loss Factor Experiment

This subchapter consists of literature review on the tools and method used to conduct the experiment in measuring solid waste volume inside dump container in LPS and determining the loss factor of solid waste during its transportation process from LPS to TPA. The method to determine characteristics of LPS, to design the experiment, and to analyze the weight reduction factor is presented.

2.5.1 LPS Characteristics Determination

There are 37 LPS that being served by private companies for its solid waste transportation activity. Thus the study is focusing in finding out conversion factor from volume into tonnage from these 37 LPS. Sampling method is chosen regarding its ease and time cost saving compare to total observation method. Sampling location has to be correctly determined to ensure that data collected has well represented total population.

2.5.1.1 Analytical Hierarchy Process (AHP) Definition

The Analytic Hierarchy Process (AHP) is a theory of measurement through pairwise comparisons and relies on judgments of experts to derive priority scales (Saaty, 2008). It is these scales that measure intangibles in relative terms. The comparisons are made using a scale of absolute judgments that represents how much more; one element dominates another with respect to a given attribute.

Simone from University of Sienna, wrote in his lecture note, The Analytical Hierarchy Process (AHP) which introduced by Thomas Saaty (1980) is an effective tool for dealing with complex decision making, and may aid the decision maker to set priorities and make the best decision. By reducing complex decision to a series of pairwise comparisons, and then synthesizing the results, the AHP helps to capture both subjective and objective aspects of a decision. In addition, the AHP incorporates a useful technique for checking the consistency of the decision maker`s evaluations, thus reducing the bias in the decision making process.

The AHP generates a weight for each evaluation criterion according to the decision maker`s pairwise comparisons of the criteria. The higher the weight, the more important the corresponding criterion. Next, for a fixed criterion, the AHP assigns a score to each option according to the decision maker`s pairwise comparisons of the options based on that criterion. The higher the score, the better the performance of the option with respect to the considered criterion. Finally, the AHP combines the criteria weights and the options scores, thus determining a global score for each option, and a consequent ranking. The global score for a given option is a weighted sum of the scores it obtained with respect to all the criteria.

2.5.1.2 The Analytic Hierarchy Process

To make a decision in an organized way to generate priorities, decomposition of the decision is needed and done into the following steps.

1. Define the problem and determine the kind of knowledge sought.

2. Structure the decision hierarchy from the top with the goal of the decision, then the objectives from a broad perspective, through the intermediate levels (criteria on which subsequent elements depend) to the lowest level (which usually is a set of the alternatives).
3. Construct a set of pairwise comparison matrices. Each element in an upper level is used to compare the elements in the level immediately below with respect to it.
4. Use the priorities obtained from the comparisons to weigh the priorities in the level immediately below. Do this for every element. Then for each element in the level below add its weighed values and obtain its overall or global priority. Continue this process of weighing and adding until the final priorities of the alternatives in the bottom most level are obtained.

Table 2. 13 The fundamental scale of absolute numbers

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
2	Weak or slight	
3	Moderate importance	Experience and judgment slightly favor one activity over another
4	Moderate plus	
5	Strong importance	Experience and judgment strongly favor one activity over another
6	Strong plus	
7	Very strong or demonstrated importance	An activity is favored very strongly over another; its dominance demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation

Source : Saaty, 2008

2.5.1.3 Expert Choice

Expert choice is a collaborative decision support software and hardware system that facilitates group decisions that are more efficient, analytical, and justifiable (Rodriguez, 2005). It is widely used to support analytical process of

AHP. The software allows real-time interaction of management teams to achieve consensus on decisions. It also provides other functions, for instance;

- structure for the entire decision making process
- a tool that facilitates collaboration between multiple stakeholders
- analytical decision making
- improved communication
- usually a faster decision
- documentation of the decision making process
- a consensus decision and ultimately better and more justifiable decisions

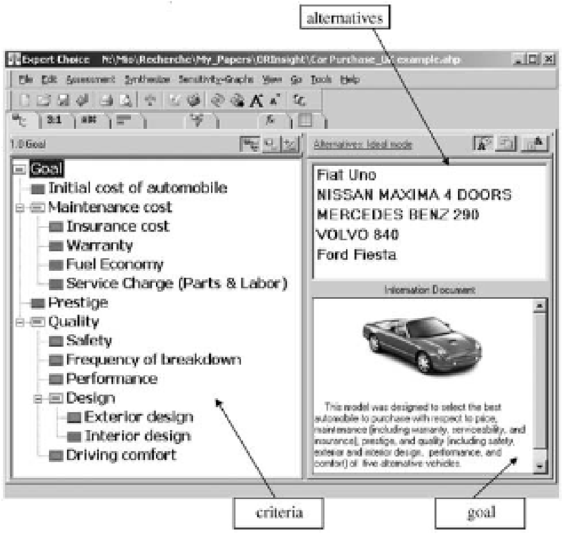

Figure 2. 3 Example of Hierarchy in Software Expert Choice (Source : Ishizaka, 2009)

2.5.2 Measurement Method of Solid Waste Generation

The amount of solid waste generation in municipality can be obtained by conducting direct survey or direct measurement. According to SNI, there are four methods that can be used to conduct the measurement, which are:

1. Measuring the amount of solid waste produced by a number of sample (residential or non residential) which randomly determined in proportional number and conducted for 8 days in a row (SNI 19-3964-1995 and SNI M 36-1991-03)
2. Load-count analysis: Measuring the sum or the total of solid waste (weight and/or volume) transferred to LPS, for example the amount of

solid waste collected by garbage carts for 8 days in a row. By knowing the amount and the characteristics of solid waste collected by every garbage men, the amount of solid waste produced per person can be defined as well.

3. Weight-volume analysis: if weight bridge is available, then the amount of solid waste entering landfill from every sources can be easily defined at any particular time. The number of solid waste produced per person can be obtained by dividing the daily amount of solid waste with the total number of residents and public service nearby the dumping site.
4. Material balance analysis: a detail and comprehensive analysis of solid waste composition by analyzing the flow of incoming solid waste, the lost solid waste in the system, and the residual or the waste itself in particular system boundary.

To conduct a proper survey, the frequency of data collection must be done in eight days in a row to show if there is any daily fluctuation. It is then continued with monthly survey to show the occurrence of fluctuation within one year. The frequency of conducting solid waste measurement in Indonesia itself has been simplified as following:

a. One day survey
b. One week survey, the data is collected every 2 or 3 days
c. 8 days in a row

2.5.3 Uniformity Test

Data is said to be uniform when it falls in between upper control limit and lower control limit. Uniformity test is done using following equation

$$UCL = x + L\overline{\sigma} \quad \ldots\ldots\ldots\ldots (2.7)$$

$$\text{Center line} = \overline{x}$$

$$LCL = x - L\overline{\sigma} \quad \ldots\ldots\ldots\ldots (2.8)$$

L is the distance of the control limits from the center line, expressed in standard deviation units. This general theory of control charts was first proposed by Walter A. Shewhart, and control charts developed according to these principles are often called Shewhart control charts.

Regardless of the distribution of the quality characteristic, the distance of control limits usually chosen is three; hence, **three-sigma limits** are customarily employed on control charts, regardless of the type of chart employed. The use of three-sigma control limits is typically justified on the basis that they give good results in practice.

Specifying the control limits is one of the critical decisions. By moving the control limits farther from the center line, the risk of a type I error is decreased. That is, the risk of a point falling beyond the control limits, indicating an out-of-control condition when no assignable cause is present. However, widening the control limits will also increase the risk of a type II error. That is, the risk of a point falling between the control limits when the process is really our of control.

2.5.4 Adequacy Test

Adequacy test is done to check whether the amount of data collected has sufficient to be processed in order to continue the analysis of the research. To calculate the minimum number of data needed for accuracy level 5% and confidence level 95% is following the equation:

$$N' = \left[\frac{\frac{C}{\alpha}\sqrt{N\sum_{i=1}^{N}x_i^2 - (\sum_{i=1}^{N}x_i)^2}}{\sum_{i=1}^{N}x_i}\right]^2 \quad \ldots\ldots\ldots\ldots (2.9)$$

C = 2
α = 0.05

Data is adequate if N ≥ N'

Data is inadequate if N ≤ N'

2.5.5 Fitting Distribution using BestFit @Risk

BestFit is a Windows program which finds the distribution that best fits the input data. Automatic goodness of fit testing will show at a glance the accuracy of BestFit`s answers. Fitting distribution to data is important because if the distribution selected is wrong, any analysis being run could have serious errors that can cost time and money. If the data is generated by a random process, the best modeling results to obtain is by accurately describing that process. And the best way to do that is with fitted probability distributions (Palisade Corporation, n.d.).

BestFit`s goal is to find the distribution that best fits the input data. BestFit does not produce an absolute answer; it identifies a distribution that most likely produced the data. For a given distribution, BestFit looks for the parameters of the function that optimize the goodness of fit, a measurement of the probability that the input data was produced by the given distribution. Always evaluate the BestFit results quantitatively and qualitatively, examining both the comparison graphs and statistics before using a result. BestFit goes through in the following steps when finding the best fit for the input data:

- For input sample data, parameters are estimated using maximum-likelihood estimators. For density and cumulative data, the method of least squares is used to minimize the distance between the input curve points and the theoretical function.
- Fitted distributions are ranked using one or more fit statistics, including Chi-square, Anderson-Darling, and Komolgorov-Smirnov.

BestFit gives all the needed information to decide which fit is the best, and whether that fit is good enough to use. All results, including graphs, statistics and distribution functions, can easily be transferred to other programs for further analysis and presentation.

By using probability distributions, variables can have different probabilities of different outcomes occurring. Probability distributions are a much more realistic way of describing uncertainty in variables of a risk analysis. Common probability distributions include:

- Normal – Or "bell curve." The user simply defines the mean or expected value and a standard deviation to describe the variation about the mean. Values in the middle near the mean are most likely to occur. It is symmetric and describes many natural phenomena such as people's heights. Examples of variables described by normal distributions include inflation rates and energy prices.

- Lognormal – Values are positively skewed, not symmetric like a normal distribution. It is used to represent values that don't go below zero but have unlimited positive potential. Examples of variables described by lognormal distributions include real estate property values, stock prices, and oil reserves.
- Uniform – All values have an equal chance of occurring, and the user simply defines the minimum and maximum. Examples of variables that could be uniformly distributed include manufacturing costs or future sales revenues for a new product.
- Triangular – The user defines the minimum, most likely, and maximum values. Values around the most likely are more likely to occur. Variables that could be described by a triangular distribution include past sales history per unit of time and inventory levels.
- PERT- The user defines the minimum, most likely, and maximum values, just like the triangular distribution. Values around the most likely are more likely to occur. However values between the most likely and extremes are more likely to occur than the triangular; that is, the extremes are not as emphasized. An example of the use of a PERT distribution is to describe the duration of a task in a project management model.
- Discrete – The user defines specific values that may occur and the likelihood of each. An example might be the results of a lawsuit: 20% chance of positive verdict, 30% change of negative verdict, 40% chance of settlement, and 10% chance of mistrial.

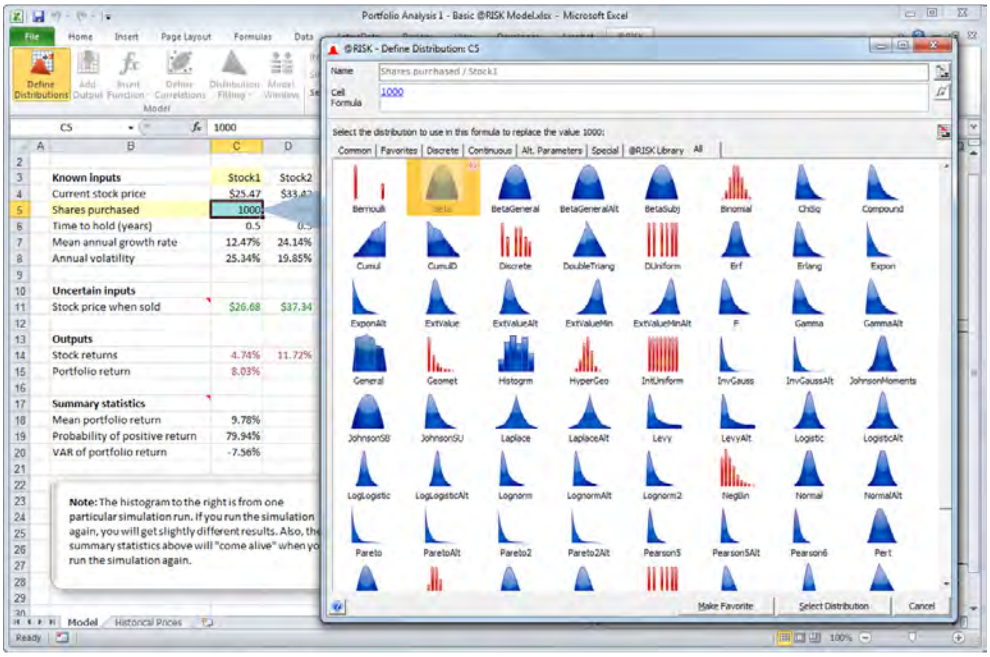

Figure 2. 4 @Risk Distribution Pallette (Source: Palisade Corporation, 2016)

2.5.6 Design of Experiment

Design of Experiments (DOE) is a powerful technique used for exploring new processes, gaining increased knowledge of the existing processes and optimizing these processes for achieving world class performance (Anthony, 2003). DOE is the method used in conducting on-site weight scaling experiment. The methodology of DOE is fundamentally divided into four phases:

Planning Phase

There are several important steps in planning phase. The first step is defining a clear and succinct statement of the problem; it can create a better understanding of what needs to be done. The selection of a suitable response for the experiment is critical to the success of any industrial designed experiment. The response can be variable or attribute in nature. Experimenters should define the measurement system prior to performing the experiment in order to understand what to measure, where to measure, which is doing the measurement so that various components of variation can be evaluated.

The next process is selection of process variables or design parameters. This is a very important step of the experiment design procedure. Some possible ways to identify potential process variables are the use of engineering knowledge of the process, historical data, cause and effect analysis and brainstorming. Having identified the process variables, the next step is to classify them into controllable and uncontrollable variables. Controllable variables are those which can be controlled while uncontrollable variables (noise variables) are those which are difficult to control.

The following step is determining the levels of process variables. The number of levels depends on the nature of the process variable and whether or not the chosen process variable is qualitative (e.g.: type of catalyst, type of material, etc.) or quantitative (temperature, speed, pressure, etc.). For quantitative process variables, two levels are generally required. However for qualitative process variables, more than two levels may be required. The last step in planning phase is listing all the interaction of interest. The best way to relate to interaction is to view as an effect, just like a factor or process variable effect. The number of two order interaction within an experiment can be easily obtained by using a simple equation:

$$N = \frac{n\,x\,(n-1)}{2} \quad \ldots\ldots\ldots\ldots(2.10)$$

Designing Phase

Experiments can be statistically designed using classical approach advocated by Sir Ronald Fished, orthogonal array approach advocated by Dr Genichi Taguchi or variables search approach promoted by Dr. Dorian Shainin. The size of the experiment is dependent on the number of factors and/or interactions to be studied, the number of levels of each factor, budget and resources allocated for carrying out the experiment. During the design stage, it is quite important to consider the confounding structure and resolution of the design. It is good practice to have the design matrix ready for the team prior to executing the experiment.

Conducting Phase

This is the phase in which the planned experiment is carried out and the results are evaluated. Selection of suitable location for carrying out the experiment is important. As well as the availability of materials/parts, operators, machines, etc.. Assessment of the viability of an action in monetary terms by utilizing cost-benefit analysis needs to be conducted also to justify that the benefits to be gained from the experiment will exceed the cost of the experiment.

While performing the experiment, there are several steps that needs to be concerned. The person responsible for the experiment should be present throughout the experiment to reduce the operator-to-operator variability. The experimental trials needs to be monitored to avoid any discrepancies while running the experiment. And data sheet or excel file have to be prepared to record the observed response values.

Analyzing Phase

Having performed the experiment, the next phase is to analyze and interpret the results so that valid and sound conclusions can be derived. Following are the possible objectives to be achieved, which are determination of design parameters or process variables that affect the mean process performance, the performance variability, that yield the optimum performance and determination of further improvement possibility.

CHAPTER III

RESEARCH DESIGN AND METHODOLOGY

This chapter consists of the explanation regarding design and methodology used in the research. It covers the steps done at beginning of the research until the method used to obtain research objectives.

3.1 Research Methodology

The method used in research is presented in methodology flowchart as follow:

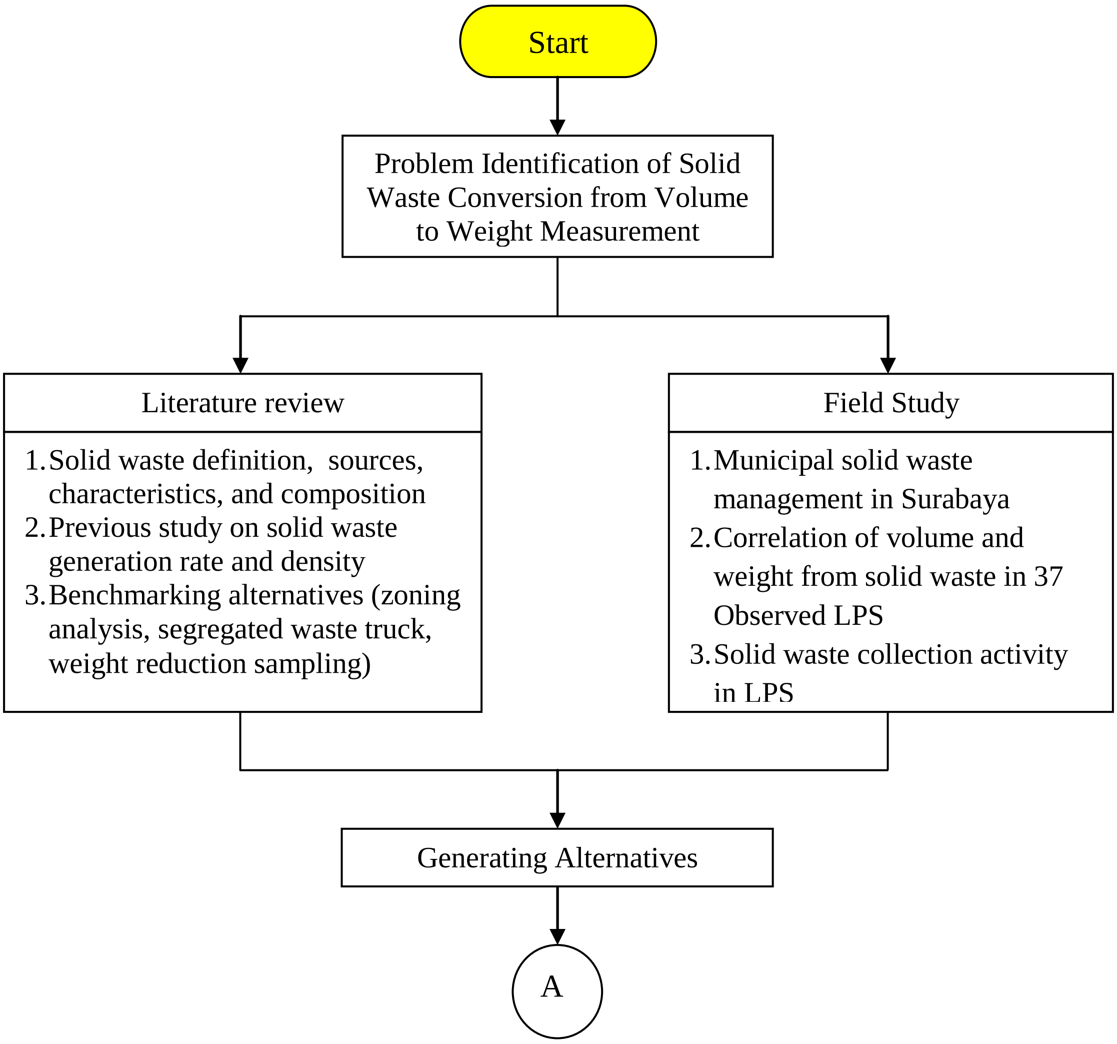

Figure 3. 1 Research Methodology Flowchart

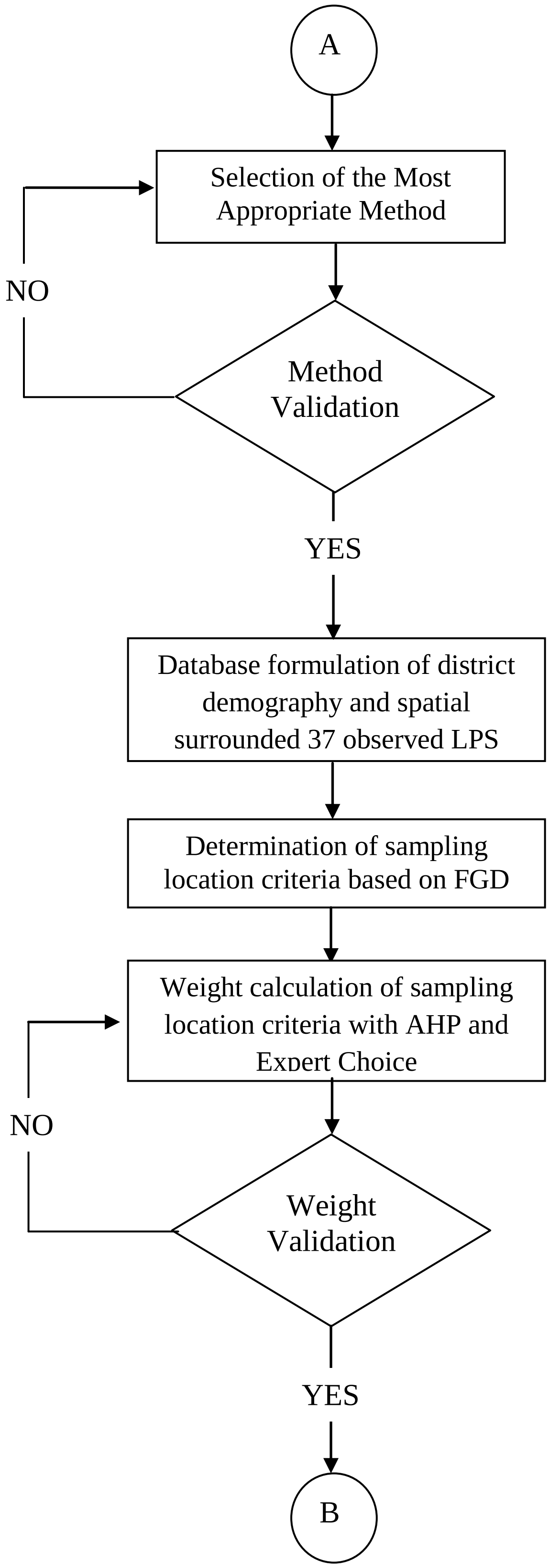

Figure 3.1 Research Methodology Flowchart (Cont`d)

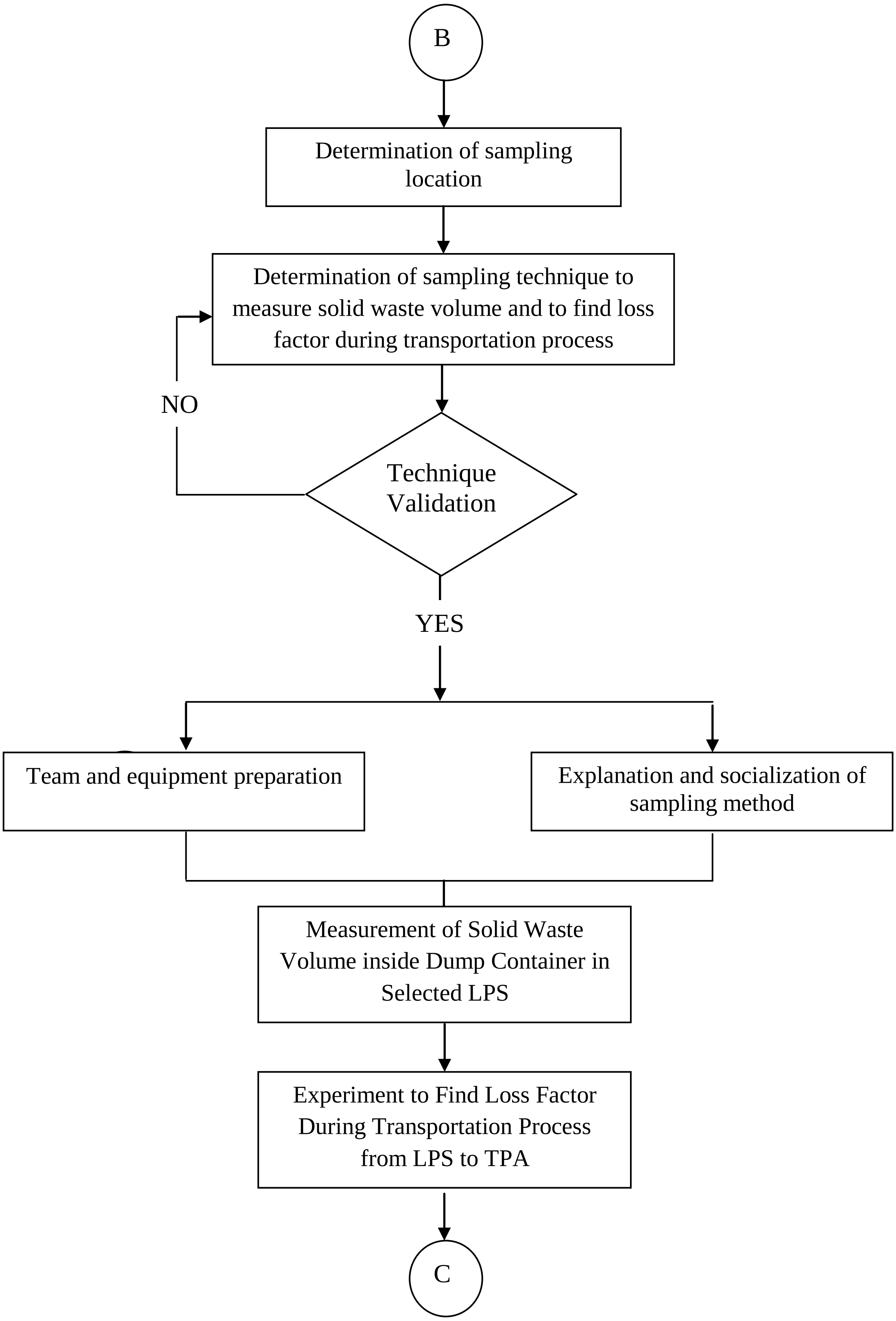

Figure 3.1 Research Methodology Flowchart (Cont`d)

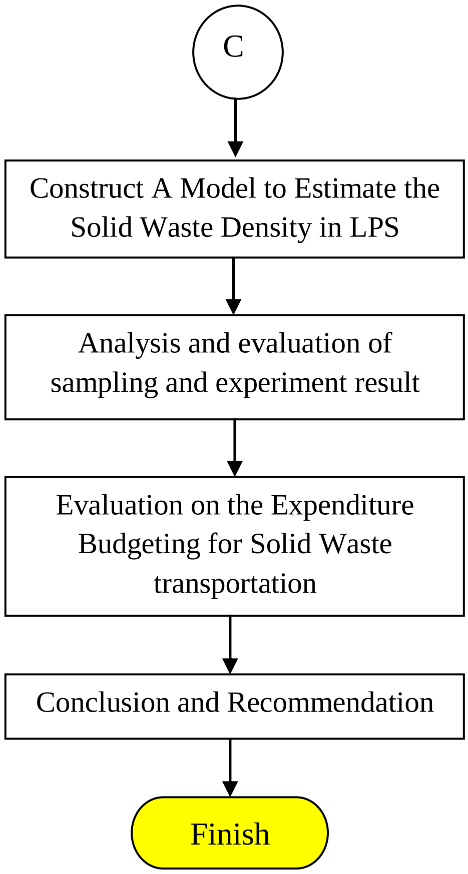

Figure 3.1 Research Methodology Flowchart (Cont`d)

3.2 Problem Identification of Solid Waste Conversion from Volume to Weight Measurement

In this stage, brainstorming with Dinas Kebersihan dan Pertamanan Kota Surabaya is done to identify the problems related to payment system in solid waste transporting activity from LPS to TPA which done by partners (private companies). The identified problem is mainly concerned on converting the existing payment method which using volume unit basis into new payment method which expected to use weight unit basis.

3.3 Literature Review and Field Study

The next stage after the problems has been identified is to collect and to study the literature related to municipal solid waste in order to well understanding system of the problem. Since the problem is focusing on solid waste management in Surabaya, thus it is necessary to conduct a field study related to the object observation and to understand the correlation between volume and weight of solid waste in 37 observed LPS. Benchmark on proposed alternatives is conducted as well in order to generate the alternatives of problem solution.

3.4 Generating Alternatives and Selection of the Most Appropriate Method

In this stage, brainstorming of several possible alternatives is conducted by evaluating the result of literature review from previous stage. From brainstorming process, three possible alternatives are generated and will be analyzed in following stage regarding their benefits and constraints. The first alternative is conducting sampling on selected LPS to figure out the reduction weight of solid waste being transported from LPS to TPA. The second proposed alternative is segregated waste truck which done by analyzing benefit and cost of the implementation. The third alternative is using statistical analysis by zoning LPS area and sampling the density of solid waste generation.

The objective of on-site weight scaling experiment is to determine the factor of weight reduction during transportation of solid waste from LPS to TPA. It is presumed that the solid waste weight in LPS is higher than the solid waste weight in TPA. This is due to several factors such as compaction, distance, and solid waste composition. The reduction value can be vary among LPS depend on these factors. Thus experiment of scaling the weight of solid waste in LPS is conducted in order to obtain the actual weight in LPS. Then the result will be compared with weight recorded in TPA using weighbridge. The result of experiment is analyzed to determine the factor uncertainties affecting the reduced weight from LPS to TPA.

Segregated truck container is the concept of installing compartment inside dump truck and providing segregation activity during transportation activity. Developed country like United Kingdom has implemented this mode of solid waste transportation which enable government to segregate solid waste right from the sources until it reach the end disposal site. Having compartment inside dump truck also enables to measure the density of each solid waste composition when it is being transported. Analysis of benefit and cost in investing segregated dump truck is necessary to be done also in order to determine the feasibility of having new mode of solid waste transportation.

The objective of statistical analysis using zoning method is to determine the most appropriate density for each cluster of LPS. Knowing that each area generally generates different amount of solid waste, thus it is necessary to find the range of density that can well represent the factor conversion for overall 37 LPS. The next step is evaluating density known from previous study. The density to be evaluated is taken from JICA study with density factor 0.305 ton/m^3, Tchobanoglous book with density factor 0.3558 ton/m^3, DKP study in 2014 with density factor 0.288 ton/m^3 and ITB study with density factor 0.302 ton/m^3. The evaluation is using statistical method which is correlation, linear regression, and error measurement analysis. Density with smallest error value is estimated as the density that well representing conversion factor than other density values. The most appropriate density that has been defined is used to estimate the solid waste transportation cost. This estimated cost is compared with the actual cost incurred to DKP and the result enables to justify whether the expenditure is exceed the estimated cost or not.

The selection of the most appropriate method is done by considering the benefits and constraints of each alternative. Feasibility of conducting the method is also becoming the concern as well. The selected method will have to be validated by Dinas Kebersihan dan Pertamanan expert, Pak Hebi as the Head of Operational Division in DKP, before being executed.

3.5 Database Formulation of District Demography and Spatial Surrounded 37 Observed LPS

After determining the most appropriate method to use in this research, the next step is to formulate a database consists of information regarding district demography and spatial surrounded 37 observed LPS. This database will be useful to define the characteristics of each LPS according to the type of solid waste sources nearby each LPS. The database formulation is started with gathering data of nearby region served by each LPS, in this scope the region is divided into

RT/RW. The next step is to conduct direct observation in the nearby region of each LPS to gather the spatial data from each region.

3.6 Determination of Sampling Location Criteria Based on FGD

From the total 37 observed LPS, there will be only some LPS selected as the sampling object as the representative of the overall LPS. In order to ensure that the selected LPS accommodate the characteristics of overall LPS, appropriate selection technique must be applied. The technique used to decide the sampling location is AHP (Analytical Hierarchy Process) with the help of software Expert Choice. The goal or the expected outcome from this decision analysis technique must be defined first and then continued with determining the decision criteria. The determination of sampling location criteria is done by FGD (Forum Group Discussion) which will be attended with the experts from DKP. The weight from each criterion will also be discussed in order to define the level of importance from each criterion as the basis of decision consideration. The weight determination is done together with the experts from DKP to validate the decision before being executed to following stage.

3.7 Selection of Sampling Location

After determining criteria to select the sampling location, the next step is to conduct assessment for each possible sampling location. The total of 37 observed LPS is assessed using the database that has been formulated previously. Score will be given to each possible sampling location and will be summed up to gain the total score. This total score represents the characteristics score of each LPS according to its generation of solid waste. The LPS will be grouped in the certain range of characteristics score in order to cluster the LPS. LPS within the same cluster indicates that they have similar characteristics in generating solid waste. One LPS from each cluster will be selected as the sampling location in order to accommodate the result of all characteristics range. The selection of sampling location is done together with Dinas Kebersihan dan Pertamanan expert, Pak Hebi as the Head of Operational Division in DKP, to validate the decision before being executed to following stage.

3.8 Determination of Sampling Technique

The next step is to determine sampling technique that will be used for the experiment. The early sequence in formulating design of experiment is applied which is planning and designing to ensure that the technique applied is appropriate and effective. The implemented technique is taken following sampling guideline that has been defined in SNI (Standard National Indonesia) to find the solid waste generation in particular sources. The determination of sampling technique is done together with Dinas Kebersihan dan Pertamanan expert, Pak Hebi as the Head of Operational Division in DKP, to validate the decision before being executed to following stage.

The material, equipment and sources are prepared before the experiment started. Socialization is part of necessary process to do as well because the experiment is involving many human sources. Good communication and coordination must be applied as well to ensure the experiment run as its planned and to minimize the error occurred during the experiment.

3.9 Evaluation of Expenditure for Solid Waste Transportation

The data obtained from the experiment will be used to develop a payment model that can be used by DKP to pay partners for the solid waste transportation activity from LPS to TPA. The new model is expected to elaborate clear analysis about the payment components and the result is expected to give fair total payment given to partners. In order to recommend a fair payment mechanism to partners, analysis from the amount of solid waste weight per m^3 volume is needed in order to figure out the variety of solid waste amount being transported from each LPS.

3.10 Conclusion and Recommendation

This chapter consists of conclusion from the research and objective achievements towards finding solution to the problems. This chapter also consists of recommendation from the research as basis of improvement in future research.

CHAPTER IV
IDENTIFICATION OF METHOD ALTERNATIVES

This chapter consists of the identification of proposed method alternatives that can be used to solve the identified problems mentioned in this research. The method of each alternative is elaborated and continued with the analysis of each benefits and constraints in the implementation. From comparison of each alternative, the next required step is to select the most appropriate method that can be used in this research.

4.1 Alternative 1: On-Site Weight Scaling Experiment

The objective of on-site weight scaling experiment is to conduct direct measurement of solid waste weight in LPS before being transported to TPA. Because in the upcoming system it is expected the new system will use weight as the basis of payment, then having more accurate scaling equipment can provide the fairer payment.

It is presumed that the solid waste weight in LPS is higher than the solid waste weight in TPA. This is due to several factors such as compaction, distance, solid waste composition, and the road surface. The reduction value can be vary among LPS depend on these factors. Thus experiment of scaling the weight of solid waste in LPS is conducted in order to obtain the actual weight in LPS. Then the result will be compared with weight recorded in TPA using weighbridge to find the total amount of weight loss during the trip. Figure 4.3 shows the steps to conduct this method.

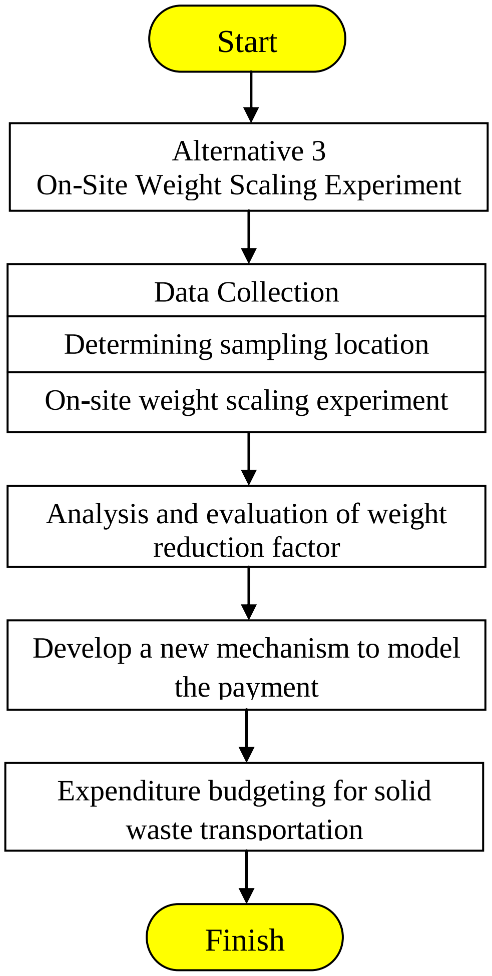

Figure 4. 1 Flowchart of On-Site Weight Scaling Experiment

4.1.1 Technique of On-Site Weight Scaling Experiment

Design of experiment (DOE) is used as the technique to conduct the experiment which consists of four phases, which is planning, designing, conducting and analyzing phase. In planning phase, a clear statement of the problem is defined which is to analyze the weight loss during transportation process from LPS to TPA. The suitable response for the experiment is the amount of weight loss which affected by the distance, the solid waste composition, and the road condition as process variables. In planning phase, the preparation of where to measure and how to measure must be done carefully. Thus selection of sampling location and technique sampling is defined properly. Selection of sampling location is conducted by analyzing LPS characteristics in order to determine the most appropriate location for experiment. AHP and Expert Choice is used as the method to define the LPS characteristics.

Defining technique sampling is one of critical step in planning phase. Proper equipments must be chosen in order to minimize the error during execution. The chosen equipment to conduct this experiment is portable truck scale which will be used to measure the weight of solid waste in LPS before it is being transported to TPA. With its ability to be carried and moved portable, it can measure the weight of solid waste from different LPS locations in more efficient way. Figure 4.2 shows the portable truck scale that will be used to execute the experiment.

Figure 4. 2 Portable Truck Scale

After planning phase, the next is designing phase which done by preparing the size of the experiment and the design matrix ready to execute the experiment. The next step after designing phase is conducting phase which the planned experiment is carried out and the results are evaluated. While performing the experiment, there are several steps that need to be concerned. The person responsible for the experiment should be present throughout the experiment to reduce the operator-to-operator variability. Thus socialization of the experiment must be done to people who work in LPS, DKP partners, and partner staffs so that the experiment can be executed properly as its planned. The experimental trials need to be monitored to avoid any discrepancies while running the experiment.

And data sheet or excel file have to be prepared to record the observed response values.

Having performed the experiment, the next phase is to analyze and interpret the results so that valid and sound conclusions can be derived. The result of experiment is analyzed to figure out the factor uncertainties affecting the reduced weight from LPS to TPA.

4.2 Alternative 2: Analysis of Segregated Truck Container

Segregated truck container is the concept of installing compartment inside dump truck and providing segregation activity during transportation activity. Developed country like United Kingdom has implemented this mode of solid waste transportation which enable government to segregate solid waste right from the sources until it reach the end disposal site. Having compartment inside dump truck also enables to measure the density of each solid waste composition when it is being transported. Thus by having new design of compartment, the disparity of density among LPS is reduced and conversion factor from volume to weight of solid waste can be defined more accurately. Figure 4.3 shows the step to conduct this method.

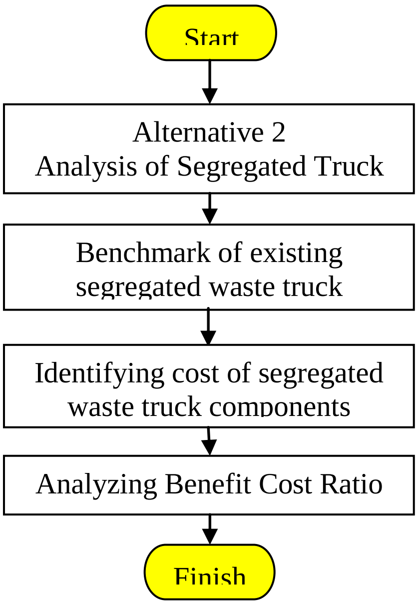

Figure 4. 3 Flowchart of Analysis of Segregated Truck Container

In Indonesia, this mode of dump truck is not commonly used yet. The existing dump truck that is commonly used now is compactor dump truck. However for dump truck used by partners in conducting the solid waste transportation activity is dump truck with conventional container. Thus the analysis of components is required in re-designing process.

Analysis of benefit and cost in investing segregated dump truck is necessary to be done also in order to determine the feasibility of having new mode of solid waste transportation.

4.2.1 Benchmark of Existing Segregated Truck Container

There are two countries that have implemented segregated truck container to transport solid waste from sources which usually are residential areas to the disposal sites. Those two countries are United Kingdom and Malaysia. In United Kingdom, this transportation activity is managed by partnership with private company under name Somerset Waste Partnership. This company uses collection vehicles which the container is divided into several compartments. The main function of this vehicle is to support the transportation of both recyclable items and non recyclable or refuse items from the sources or residential areas. The recycling collection vehicles are loaded from the sides, whereas loading of a refuse vehicle takes place from the rear.

Figure 4. 4 Sides Design of SWP Segregated Waste Vehicles – United Kingdom

The sizes and weights of vehicles vary and change over time. Thus the company provides range of vehicle specification given in SWP Waste Collection Vehicle Specifications. However the limitation of this vehicle is that it can only travel along roads that have been constructed to specific adoptable highway standards. Where a road is un-adopted, an area must be created for a suitable bin collection area adjacent to the highway. The collection point for dwellings supplied with individual containers is from curtiledge nearest the public highway (providing vehicular access for collection vehicles).

Figure 4. 5 Rear Design of SWP Segregated Waste Vehicles – United Kingdom

While in Malaysia, the use of segregated truck container for their solid waste vehicle is newly implemented since September 2014. The use of this vehicle is to support the trash separation process according to types which is managed under the Solid Waste and Public Cleansing Management Act 2007 (Act 672). There are eight states in Malaysia that have used this vehicle in their system, which are Kuala Lumpur, Putrajaya, Pahang, Johor, Malacca, Negeri Sembilan, Perlis and Kedah. The Malaysian Government in partnership with Alam Flora Sdn Bhd provides segregated dump truck going around the states to collect the separated waste.

Figure 4. 6 Alam Flora Segregation Trucks - Malaysia

Not only to ease the collection of separated waste from residential areas, but the use of this vehicle is one of the Malaysian Government attempt in taking serious action in managing the waste within their states. Inspired by waste management implemented in developed countries like Sweden, Malaysian Government mandates their people to understand their responsibility to take care the environment and to be more aware with the daily waste they produced. To drive home the message, the corporation is planning more education and awareness campaigns nationwide.

4.2.2 Benefit and Cost Analysis of Segregated Truck Container

There are some benefits and cost component if this method is implemented in this research. Regarding the research objectives, by using segregated truck container for the dump vehicle, the benefit of this method is that it can reduce the disparity of solid waste density in LPS. In the existing system, the waste being transferred to LPS consists of mix composition of solid waste. Density of mixed solid waste tends to differ from one another due to many factors such as the storage sites, the composition, and the compaction. Another way to figure out the more accurate density of solid waste in LPS is by separating the composition of its mixed waste. Density of specific waste type tends to be similar if the variable of storage volume is controlled.

Another benefit of using segregated truck container is to support the waste separation from sources until the waste being disposed to landfill. Thus the control of waste separation activity is not stopped in the sources or residential areas only, but it can be continued in the following process of waste collection and transferring. By having better control of waste separation in the system, the economical value of waste separation can be maximized as well. When the waste being collected is mixed into one container, the recyclable items may be damaged and may lead to decrease of its quality and economical value.

However the existing dump containers consist of one storage only, thus this method will require the re-design of dump container into segregated truck container to provide storage of separated waste. The process of re-designing dump container itself requires thorough analysis of the compartment dimension, the components specification and the cost calculation of the overall required budget to invest.

Another cost components as the consequences of implementing this new model of vehicle is the education and socialization towards the waste separation activities. The use of this vehicle will not work effectively if there is no proper separated waste done along the process before the wastes reach LPS. Even though in some areas have implemented waste separation in their home, but once the waste being collected by garbage men the separation process is stop continuing. Thus the education must be done to the garbage men also since they are part of stakeholders that involve in the municipal solid waste management.

Because the cart used by garbage men consists of only one container space thus it is not able to facilitate the waste separation. The garbage men are also used to dispose directly everything in the home garbage bins into their cart containers. Therefore the cost consequence may lead to the investment of separated cart container used by garbage men to collect waste from source to LPS.

4.3 Alternative 3: Statistical Analysis Using Zoning Method

The objective of statistical analysis using zonig method is to determine the most appropriate density of solid waste for each cluster of LPS. As it is known that to convert volume into weight unit or vice versa, density is normally used as the conversion factor. Knowing that each area generally generates different amount of solid waste, thus it is necessary to find the range of density that can well represent the factor conversion for overall 37 LPS. Figure 4.1 presents the steps to conduct this method.

Database of district demography and spatial surround 37 observed LPS is formulated to identify the characteristics of solid waste sources. As the composition of mixed solid waste is formed from the source, thus the solid waste generation can be traced from its sources. The area with same characteristics is clustered in the same group. It is presumed that the same characteristics indicate the same density factor.

In order to evaluate the hypothesis that LPS with the same characteristic having same or similar density factor, some density factor known from previous study is being evaluated first. These density factors are taken from four sources, which are: JICA study with density factor 0.305 ton/m^3, Tchobanoglous book with density factor 0.3558 ton/m^3, DKP study in 2014 with density factor 0.288 ton/m^3 and ITB study with density factor 0.302 ton/m^3. The purpose of this evaluation is to determine which density factor that fit most for all LPS by analyzing its estimation error value. The analysis is done using statistical techniques which are correlation, linear regression, and error measurement analysis. Density with smallest error value is estimated as the density that well representing conversion factor than other density values.

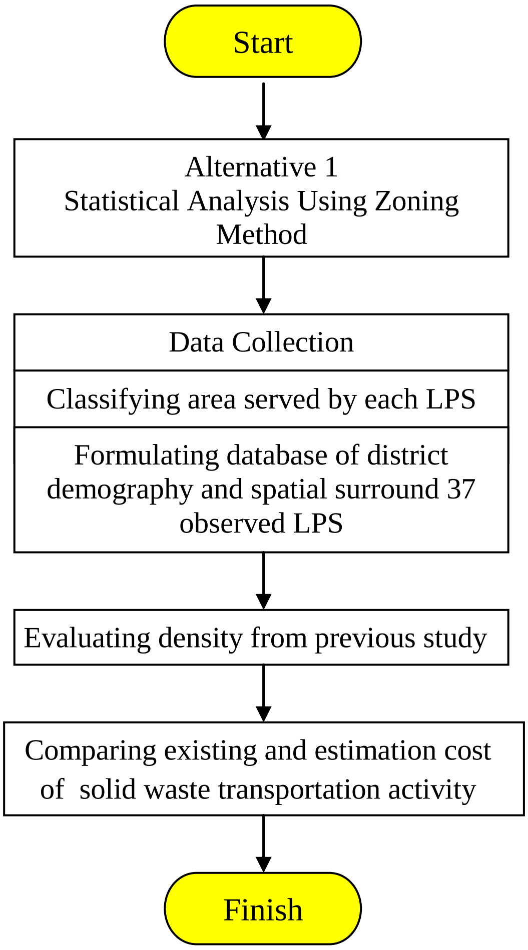

Figure 4. 7 Flowchart of Statistical Analysis Using Zoning Method

The most appropriate density that has been defined is used to estimate the solid waste transportation cost. This estimated cost is compared with the actual cost incurred to DKP and the result enables to justify whether the expenditure is exceed the estimated cost or not.

4.3.1 Evaluation of Estimated Density of Municipal Solid Waste in Surabaya taken from Previous Study

There have been several researches studying density of solid waste in Surabaya. However with the growth of population and other factors like economic growth and consumption growth, it is necessary to check whether the result is still relevant or not to today`s condition of municipal solid waste in Surabaya.

Density refers to weight of solid waste per unit volume. It is used to represent characteristics of solid waste in particular condition and the value can be vary depend on the facilities used and the composition of the solid waste. In this research, the range of density to be found is the value that represents density of solid waste in LPS (temporary solid waste disposal site) which using dump container to facilitate the transferring process of solid waste.

The technique to evaluate the relevance of municipal solid waste density known from previous studies to be used as the conversion factor to estimate volume of solid waste transferred to LPS is using forecast or estimated error. The error measures how closely the model fits the actual data at each point. The estimated error is computed by comparing the trend line of estimated value with actual past data. The actual past data used in this computation is the volume and weight of solid waste being transported from LPS to TPA within range of one year period. Three commonly measures of fit are Mean Squared Error (MSE), Mean Absolute Deviation (MAD) and Mean Absolute Percentage Error (MAPE). These error measures are particularly helpful to compare four estimated density factors. The values that give smallest MSE, MAD or MAPE is generally considered to provide the best fit. Table 4.1 is the example of table used to compute the estimated error of each density factor in LPS Benteng.

Table 4. 1 Comparison of Actual Weight and Estimated Weight of Solid Waste in LPS Benteng from July 2014 – June 2015

Month	Date	Volume (m3)	Actual Weight (kg)	Estimated Weight (JICA) - d = 305 kg/m3				Estimated Weight (Tchobanoglous) - d = 355.8 kg/m3				Estimated Weight (DKP 2014) - d = 288 kg/m3			
				305	MAPE	MSE	MAD	355.8	MAPE	MSE	MAD	288	MAPE	MSE	MAD
Januari	1	102	28660	31,110.00	0.09	6,002,500.00	2,450.00	36,291.60	0.27	58,241,318.56	7,631.60	29,376.00	0.02	512,656.00	716.00
	2	100	19540	30,500.00	0.56	120,121,600.00	10,960.00	35,580.00	0.82	257,281,600.00	16,040.00	28,800.00	0.47	85,747,600.00	9,260.00
	3	102	22050	31,110.00	0.41	82,083,600.00	9,060.00	36,291.60	0.65	202,823,170.56	14,241.60	29,376.00	0.33	53,670,276.00	7,326.00
	4	104	14890	31,720.00	1.13	283,248,900.00	16,830.00	37,003.20	1.49	488,993,614.24	22,113.20	29,952.00	1.01	226,863,844.00	15,062.00
	5	102	21200	31,110.00	0.47	98,208,100.00	9,910.00	36,291.60	0.71	227,756,390.56	15,091.60	29,376.00	0.39	66,846,976.00	8,176.00
	6	102	25550	31,110.00	0.22	30,913,600.00	5,560.00	36,291.60	0.42	115,381,970.56	10,741.60	29,376.00	0.15	14,638,276.00	3,826.00
	7	104	20110	31,720.00	0.58	134,792,100.00	11,610.00	37,003.20	0.84	285,380,206.24	16,893.20	29,952.00	0.49	96,864,964.00	9,842.00
	8	100	26620	30,500.00	0.15	15,054,400.00	3,880.00	35,580.00	0.34	80,281,600.00	8,960.00	28,800.00	0.08	4,752,400.00	2,180.00
	9	104	22080	31,720.00	0.44	92,929,600.00	9,640.00	37,003.20	0.68	222,701,898.24	14,923.20	29,952.00	0.36	61,968,384.00	7,872.00
	10	106	24410	32,330.00	0.32	62,726,400.00	7,920.00	37,714.80	0.55	177,017,703.04	13,304.80	30,528.00	0.25	37,429,924.00	6,118.00
	11	102	21030	31,110.00	0.48	101,606,400.00	10,080.00	36,291.60	0.73	232,916,434.56	15,261.60	29,376.00	0.40	69,655,716.00	8,346.00
	12	104	18340	31,720.00	0.73	179,024,400.00	13,380.00	37,003.20	1.02	348,315,034.24	18,663.20	29,952.00	0.63	134,838,544.00	11,612.00
	13	102	23180	31,110.00	0.34	62,884,900.00	7,930.00	36,291.60	0.57	171,914,054.56	13,111.60	29,376.00	0.27	38,390,416.00	6,196.00
	14	104	17340	31,720.00	0.83	206,784,400.00	14,380.00	37,003.20	1.13	386,641,434.24	19,663.20	29,952.00	0.73	159,062,544.00	12,612.00
	15	104	23990	31,720.00	0.32	59,752,900.00	7,730.00	37,003.20	0.54	169,343,374.24	13,013.20	29,952.00	0.25	35,545,444.00	5,962.00
…………															
Desember	**16**	102	26700	31,110.00	0.17	19,448,100.00	4,410.00	36,291.60	0.36	91,998,790.56	9,591.60	29,376.00	0.10	7,160,976.00	2,676.00
	17	104	22210	31,720.00	0.43	90,440,100.00	9,510.00	37,003.20	0.67	218,838,766.24	14,793.20	29,952.00	0.35	59,938,564.00	7,742.00
	18	104	25830	31,720.00	0.23	34,692,100.00	5,890.00	37,003.20	0.43	124,840,398.24	11,173.20	29,952.00	0.16	16,990,884.00	4,122.00
	19	104	24080	31,720.00	0.32	58,369,600.00	7,640.00	37,003.20	0.54	167,009,098.24	12,923.20	29,952.00	0.24	34,480,384.00	5,872.00
	20	104	25650	31,720.00	0.24	36,844,900.00	6,070.00	37,003.20	0.44	128,895,150.24	11,353.20	29,952.00	0.17	18,507,204.00	4,302.00
	21	102	13390	31,110.00	1.32	313,998,400.00	17,720.00	36,291.60	1.71	524,483,282.56	22,901.60	29,376.00	1.19	255,552,196.00	15,986.00
	22	104	23120	31,720.00	0.37	73,960,000.00	8,600.00	37,003.20	0.60	192,743,242.24	13,883.20	29,952.00	0.30	46,676,224.00	6,832.00
	23	104	23300	31,720.00	0.36	70,896,400.00	8,420.00	37,003.20	0.59	187,777,690.24	13,703.20	29,952.00	0.29	44,249,104.00	6,652.00
	24	104	26430	31,720.00	0.20	27,984,100.00	5,290.00	37,003.20	0.40	111,792,558.24	10,573.20	29,952.00	0.13	12,404,484.00	3,522.00
	25	102	25030	31,110.00	0.24	36,966,400.00	6,080.00	36,291.60	0.45	126,823,634.56	11,261.60	29,376.00	0.17	18,887,716.00	4,346.00
	26	84	19660	25,620.00	0.30	35,521,600.00	5,960.00	29,887.20	0.52	104,595,619.84	10,227.20	24,192.00	0.23	20,539,024.00	4,532.00
	27	124	26960	37,820.00	0.40	117,939,600.00	10,860.00	44,119.20	0.64	294,438,144.64	17,159.20	35,712.00	0.32	76,597,504.00	8,752.00
	28	102	22210	31,110.00	0.40	79,210,000.00	8,900.00	36,291.60	0.63	198,291,458.56	14,081.60	29,376.00	0.32	51,351,556.00	7,166.00
	29	102	22100	31,110.00	0.41	81,180,100.00	9,010.00	36,291.60	0.64	201,401,510.56	14,191.60	29,376.00	0.33	52,940,176.00	7,276.00
	30	102	22020	31,110.00	0.41	82,628,100.00	9,090.00	36,291.60	0.65	203,678,566.56	14,271.60	29,376.00	0.33	54,110,736.00	7,356.00
	31	104	24480	31,720.00	0.30	52,417,600.00	7,240.00	37,003.20	0.51	156,830,538.24	12,523.20	29,952.00	0.22	29,942,784.00	5,472.00
Total Measurement of Estimated Error					**45.49%**	**98,536,965.93**	**9,056.26**		**69.47%**	**220,612,035.03**	**14,188.06**		**37.68%**	**69,637,540.30**	**7,375.40**

From the example shown in the comparison of actual weight and estimated weight of solid waste in LPS Benteng, density factor from Studi DKP 2014 has the smallest percentage error of 37.68% as shown in column MAPE. Followed by other measurement error, MSE and MAD, they also show the smallest value compare to other density factors. It indicates that the result of Studi DKP 2014 in determining solid waste density in Surabaya provide the best fit in estimating the solid waste generation in LPS Benteng. However it cannot be judged directly that the density of solid waste in LPS Benteng is 288 kg/m^3, as according to the result of Studi DKP 2014. Even though it has the smallest percentage error, but the value of its percentage error is still considered high. Thus, further research to determine the most fit density factor for LPS Benteng is necessary in order to reduce the percentage error value in the estimation model.

The same computation is done for other 36 observed LPS as well to find which one from the four density factors provide the best fit of estimation. Table 4.2 shows the recapitulation of each measurement error for all 37 observed LPS.

Table 4. 2 MAPE Value from Comparison of Actual Weight and Estimated Weight of Solid Waste in 37 LPS in Surabaya

No	LPS	MAPE			
		JICA (305)	Tchobanoglous (355.8)	Studi DKP 2014(288.5)	Studi ITB (302)
1	Legundi	24.77%	23.79%	26.62%	25.04%
2	Dupak	25.20%	36.41%	23.31%	24.81%
3	Semolowaru	36.11%	43.32%	35.08%	35.87%
4	Kayoon	31.37%	23.60%	34.31%	31.88%
5	Benteng	45.49%	69.47%	37.68%	44.10%
6	Ampel	20.64%	30.95%	17.17%	20.00%
7	Rungkut Menanggal	26.82%	18.98%	30.42%	27.43%
8	Waru Gunung I&II	75.69%	94.96%	69.83%	74.62%
9	Bratang	25.83%	43.84%	21.28%	24.96%
10	Indrapura	30.06%	38.90%	27.11%	29.53%
11	Tambak Rejo	30.58%	23.04%	33.76%	31.12%
12	Kedung Anyar	25.99%	16.70%	29.53%	26.60%
13	Kangean	27.45%	33.65%	25.93%	27.16%
14	Krembangan	41.54%	49.65%	38.22%	40.99%
15	Penghela	27.84%	44.89%	23.44%	26.99%

Table 4. 3 MAPE Value from Comparison of Actual Weight and Estimated Weight of Solid Waste in 37 LPS in Surabaya (Cont`d)

No	LPS	MAPE			
		JICA (305)	Tchobanoglous (355.8)	Studi DKP 2014(288.5)	Studi ITB (302)
16	Simo Lawang	36.11%	43.32%	35.08%	35.87%
17	Bendul Merisi	17.61%	29.85%	16.33%	17.27%
18	Penjaringan	25.42%	22.51%	27.52%	25.78%
19	Kendangsari	22.75%	36.85%	20.08%	22.19%
20	Kedondong	27.81%	39.14%	26.14%	27.41%
21	Kemlaten	18.59%	26.55%	18.38%	23.63%
22	Pasar Kembang	26.21%	35.29%	25.01%	25.92%
23	Babadan Indah	24.21%	38.88%	20.90%	23.54%
24	Gebang Putih	26.72%	42.91%	22.91%	25.94%
25	Dinoyo	27.20%	34.45%	25.11%	26.81%
26	Klampis	17.73%	23.93%	17.78%	17.65%
27	Kembang Kuning	11.68%	21.04%	12.44%	11.61%
28	Tenggilis M	30.76%	46.44%	26.84%	30.00%
29	Kutisari PLN	25.18%	33.33%	24.10%	24.94%
30	Wonokusumo	18.88%	16.45%	21.57%	19.30%
31	Pagesangan	21.16%	33.05%	19.95%	20.82%
32	Karang Pilang	25.09%	40.92%	21.82%	24.49%
33	Joyoboyo	17.46%	31.31%	15.44%	16.95%
34	Kebraon	26.54%	36.70%	24.90%	26.16%
35	Babaan	30.91%	48.81%	26.36%	30.01%
36	Rungkut Alang2	30.78%	45.30%	27.33%	30.11%
37	Bogangin	14.89%	21.59%	15.69%	46.81%

Density factor that has the smallest percentage error in estimating volume of solid waste in LPS is highlighted in yellow color. The result shows among four density factors known from previous study, density of solid waste taken from Studi DKP 2014 having the best fit to most of LPS. Total there are 27 LPS that is best estimated using density factor 288 kg/m^3 taken from Study DKP 2014. Another 7 LPS is best estimated using density factor 355.8 kg/m3 which is taken from Tchobanoglus research. There are also 2 LPS that is best estimated using density factor 302 kg/m^3 which is taken from Studi ITB. While density factor taken from JICA study, 305 kg/m^3, showing the least best fit as estimation factor. There is only one LPS that is best estimated using this density.

Even though the result of error measurement shows that 288 kg/m^3 having the smallest percentage error for most LPS in Surabaya, it still cannot be judged directly that density of municipal solid waste in Surabaya is 288 kg/m^3. The percentage error itself ranged widely from 15.44% to 69.83%. The higher the error value is, the less accurate it is to be used as the estimation factor. The list of LPS that have percentage error more than 30% when it is estimated using density factor 288 kg/m^3 are LPS Semolowaru, LPS Benteng, LPS Krembangan, LPS Simolawang and LPS Waru Gunung I/II. It is likely that there is another value of density factor that represents the amount of solid waste weight per unit volume for LPS that have high percentage error.

Thus it is required to conduct direct observation in several LPS to get a comprehensive understanding about the actual system of solid waste management in the field. The purpose of this observation is also to figure out the factors that affect the variety of density factor among LPS. The observation may also lead to the necessity to conduct experiment in figuring out another density value that is more accurate to estimate the generation of solid waste in Surabaya.

4.3.2 Comparison between Actual Transportation Cost and Estimated Transportation Cost of Solid Waste Management from LPS to TPA

The purpose of figuring out the best fit density of solid waste in 37 LPS in Surabaya is to determine the amount of solid waste weight being transported per unit volume from LPS to TPA. With the upcoming plan to convert payment system from volume into weight as the payment basis, DKP needs to thoroughly re-arrange the model of transportation cost analysis to be incurred.

After evaluating four density factors from previous studies, now each LPS has its own density factor which has the smallest error percentage compare to others density factor. The next step is to try this density as the estimation factor to convert weight of solid waste into volume of solid waste. By having new volume estimation, the estimated total amount of cost incurred to DKP as the payment for solid waste transportation cost can be calculated. The result of this calculation is the estimated transportation cost, which will be compared with the actual transportation cost incurred to DKP. The actual data used in this calculation is the same past data used in the calculation of error measurement. Table 4.3 shows the example of calculating the total of estimated transportation cost incurred to DKP when applying estimated density as the conversion factor.

Table 4. 4 Comparison between Actual Transportation Cost and Estimated Transportation Cost of Solid Waste Management from LPS Benteng to TPA

Month	Date	Weight (kg)	Volume (m3)			Unit Price per m3	Distance	Transportation Cost of Solid Waste			Cost Difference
			Actual Data from	Estimated Volume 288	Volume in Contract			Cost in Contract	Cost from Actual Data	Estimated Cost	
			A1	A2	A3	B	C	D3 = A3 x B x C	D1 = A1 x B x C	D2 = A2 x B x C	E = D2 - D1
Juli 2014	1	22340	104	78	105	1,315	22	Rp 3,037,650.00	Rp 3,008,720.00	Rp 2,244,084.03	Rp (764,635.97)
	2	34190	104	119	105	1,315	22	Rp 3,037,650.00	Rp 3,008,720.00	Rp 3,434,432.99	Rp 425,712.99
	3	23110	102	80	105	1,315	22	Rp 3,037,650.00	Rp 2,950,860.00	Rp 2,321,431.60	Rp (629,428.40)
	4	22610	102	79	105	1,315	22	Rp 3,037,650.00	Rp 2,950,860.00	Rp 2,271,205.90	Rp (679,654.10)
	5	33720	108	117	105	1,315	22	Rp 3,037,650.00	Rp 3,124,440.00	Rp 3,387,220.83	Rp 262,780.83
	6	16510	102	57	105	1,315	22	Rp 3,037,650.00	Rp 2,950,860.00	Rp 1,658,452.43	Rp (1,292,407.57)
	7	23450	104	81	105	1,315	22	Rp 3,037,650.00	Rp 3,008,720.00	Rp 2,355,585.07	Rp (653,134.93)
	8	35240	104	122	105	1,315	22	Rp 3,037,650.00	Rp 3,008,720.00	Rp 3,539,906.94	Rp 531,186.94
	9	13940	104	48	105	1,315	22	Rp 3,037,650.00	Rp 3,008,720.00	Rp 1,400,292.36	Rp (1,608,427.64)
	10	23240	102	81	105	1,315	22	Rp 3,037,650.00	Rp 2,950,860.00	Rp 2,334,490.28	Rp (616,369.72)
	11	29580	104	103	105	1,315	22	Rp 3,037,650.00	Rp 3,008,720.00	Rp 2,971,352.08	Rp (37,367.92)
	12	34520	102	120	105	1,315	22	Rp 3,037,650.00	Rp 2,950,860.00	Rp 3,467,581.94	Rp 516,721.94
	13	26770	104	93	105	1,315	22	Rp 3,037,650.00	Rp 3,008,720.00	Rp 2,689,083.68	Rp (319,636.32)
	14	21810	104	76	105	1,315	22	Rp 3,037,650.00	Rp 3,008,720.00	Rp 2,190,844.79	Rp (817,875.21)
	15	33920	104	118	105	1,315	22	Rp 3,037,650.00	Rp 3,008,720.00	Rp 3,407,311.11	Rp 398,591.11
………											
Juni 2015	16	18570	102	64	104	1,510	22	Rp 3,454,880.00	Rp 3,388,440.00	Rp 2,141,997.92	Rp (1,246,442.08)
	17	26080	104	91	104	1,510	22	Rp 3,454,880.00	Rp 3,454,880.00	Rp 3,008,255.56	Rp (446,624.44)
	18	22370	102	78	104	1,510	22	Rp 3,454,880.00	Rp 3,388,440.00	Rp 2,580,317.36	Rp (808,122.64)
	19	20640	102	72	104	1,510	22	Rp 3,454,880.00	Rp 3,388,440.00	Rp 2,380,766.67	Rp (1,007,673.33)
	20	29690	104	103	104	1,510	22	Rp 3,454,880.00	Rp 3,454,880.00	Rp 3,424,659.03	Rp (30,220.97)
	21	26030	104	90	104	1,510	22	Rp 3,454,880.00	Rp 3,454,880.00	Rp 3,002,488.19	Rp (452,391.81)
	22	22520	102	78	104	1,510	22	Rp 3,454,880.00	Rp 3,388,440.00	Rp 2,597,619.44	Rp (790,820.56)
	23	24430	102	85	104	1,510	22	Rp 3,454,880.00	Rp 3,388,440.00	Rp 2,817,932.64	Rp (570,507.36)
	24	19790	104	69	104	1,510	22	Rp 3,454,880.00	Rp 3,454,880.00	Rp 2,282,721.53	Rp (1,172,158.47)
	25	22370	102	78	104	1,510	22	Rp 3,454,880.00	Rp 3,388,440.00	Rp 2,580,317.36	Rp (808,122.64)
	26	26400	106	92	104	1,510	22	Rp 3,454,880.00	Rp 3,521,320.00	Rp 3,045,166.67	Rp (476,153.33)
	27	20630	102	72	104	1,510	22	Rp 3,454,880.00	Rp 3,388,440.00	Rp 2,379,613.19	Rp (1,008,826.81)
	28	22670	104	79	104	1,510	22	Rp 3,454,880.00	Rp 3,454,880.00	Rp 2,614,921.53	Rp (839,958.47)
	29	26330	102	91	104	1,510	22	Rp 3,454,880.00	Rp 3,388,440.00	Rp 3,037,092.36	Rp (351,347.64)
	30	24400	106	85	104	1,510	22	Rp 3,454,880.00	Rp 3,521,320.00	Rp 2,814,472.22	Rp (706,847.78)
								Rp 1,186,400,424.00	**Rp 1,172,309,028.00**	**Rp 889,337,049.03**	**Rp (282,971,978.97)**

Table 4.3 shows the cost comparison between the actual cost and the estimated cost of solid waste transportation from LPS Benteng to TPA (landfill). It is known that the total actual cost is higher than the total estimated cost. The total cost difference is Rp 282.971.978,97 over a year period of time. The presume is that if DKP use LPS Benteng best fit density factor to estimate the volume of solid waste being transported, which is 288 kg/m^3, then partner or private company who is responsible for this LPS suppose to earn less than the actual cost.

There is positive bias from the average of total difference between actual and estimated cost. The average of total bias is 25.10, a positive value indicates a tendency to underestimate from the actual model. This means that, on average, the density factor 288 kg/m^3 underestimate volume of solid waste by 25.10 m^3 from the actual volume. High value of bias indicates that the density used as the conversion factor to estimate volume of solid waste in LPS Benteng is inappropriate, thus the cost difference is very huge. The recapitulation of cost difference of solid waste transportation activit in every region is showed in table 4.4 until 4.7.

Table 4. 5 Cost Difference between Actual Cost and Estimated Cost of Transportation Activity

North Surabaya							
No	**LPS**	**Density Factor**	**MAPE**	**Cost from Actual Data**	**Estimated Cost**	**Cost Difference**	**Bias (m3)**
1	Dupak	288 kg/m3	23.31%	273,549,056	278,435,429	4,886,373	(0.43)
2	Ampel		24.19%	854,384,400	729,621,959	(124,762,441)	7.56
3	Babaan		26.36%	364,541,276	325,733,449	(38,807,827)	3.49
4	Benteng		37.68%	1,172,309,028	889,337,049	(282,971,979)	25.10
5	Indrapura		46.68%	224,733,388	170,564,002	(54,169,386)	4.85
6	Krembangan		71.40%	768,182,544	485,582,514	(282,600,030)	22.99
7	Wonokusum	355.8 kg/m3	16.45%	511,111,500	516,359,599	5,248,099	(0.17)
			TOTAL	**4,168,811,192**	**3,395,634,003**	**(773,177,189)**	
South Surabaya							
No	**LPS**	**Density Factor**	**MAPE**	**Cost from Actual Data**	**Estimated Cost**	**Cost Difference**	**Bias (m3)**
1	Joyoboyo	288	15.44%	876,294,900	861,254,406	(15,040,494)	1.03

Table 4. 6 Cost Difference between Actual Cost and Estimated Cost of Transportation Activity (Cont`d)

South Surabaya							
No	**LPS**	**Density Factor**	**MAPE**	**Cost from Actual Data**	**Estimated Cost**	**Cost Difference**	**Bias (m3)**
2	Bendul Merisi		16.33%	543,546,720	545,874,698	2,327,978	(0.08)
3	Kemlaten		18.38%	190,978,398	203,782,830	12,804,432	(0.84)
4	Pagesangan		19.95%	568,940,160	572,477,098	3,536,938	(0.04)
5	Babadan Indah		20.90%	117,952,550	113,091,712	(4,860,838)	0.42
6	Karang Pilang		21.82%	120,791,331	116,104,654	(4,686,677)	0.34
7	Kebraon		24.90%	338,492,930	352,186,405	13,693,475	(0.75)
8	Waru Gunung I&II		69.88%	137,815,650	126,332,453	(11,483,197)	0.79
9	Bogangin	305 kg/m3	14.89%	154,987,658	158,115,094	3,127,436	(0.20)
10	Kembang Kuning	302 kg/m3	11.61%	1,205,454,258	1,225,387,005	19,932,747	(1.41)
			TOTAL	**4,255,254,555**	**4,274,606,353**	**19,351,798**	
Central Surabaya							
No	**LPS**	**Density Factor**	**MAPE**	**Cost from Actual Data**	**Estimated Cost**	**Cost Difference**	**Bias (m3)**
1	Simo Lawang	288 kg/m3	18.97%	529,807,054	531,741,139	1,934,085	0.08
2	Penghela		23.44%	403,965,400	366,653,373	(37,312,027)	3.96
3	Pasar Kembang		25.01%	336,847,456	350,467,465	13,620,009	(1.08)
4	Kedondong		26.14%	425,752,302	432,502,504	6,750,202	(0.53)
5	Dinoyo		38.81%	418,452,424	340,024,644	(78,427,780)	6.00
6	Tambak Rejo	302 kg/m3	26.14%	2,003,562,868	1,901,254,574	(102,308,294	(9.52)
7	Kedunganyar	355.8 kg/m3	16.70%	326,549,652	371,412,979	44,863,327	(3.85)
8	Kayoon		23.60%	291,094,752	352,115,006	61,020,254	(4.86)
9	Legundi		23.79%	405,156,380	501,430,794	96,274,414	(6.86)
			TOTAL	**5,141,188,288**	**5,147,602,479**	**6,414,191**	
East Surabaya							
No	**LPS**	**Densit y Factor**	**MAPE**	**Cost from Actual Data**	**Estimated Cost**	**Cost Difference**	**Bias (m3)**
1	Kendangsari	288 kg/m3	20.08%	935,128,112	898,775,618	(36,352,494)	1.99
2	Gebang Putih		22.91%	523,975,424	490,810,809	(33,164,615)	2.01
3	Kutisari PLN		24.10%	399,327,530	449,648,344	50,320,814	(2.65)
4	Bratang		21.28%	1,173,784,222	1,049,141,421	(124,642,801)	8.59
5	Tenggilis M		26.84%	496,428,048	470,289,123	(26,138,926)	1.43
6	Rungkut Alang2		27.33%	774,546,564	725,747,668	(48,798,896)	2.89
7	Semolowaru		35.08%	482,353,920	521,180,809	38,826,889	(2.28)
8	Kangean		37.89%	531,318,630	471,978,101	(59,340,529)	5.03

Table 4. 7 Cost Difference between Actual Cost and Estimated Cost of Transportation Activity (Cont`d)

East Surabaya							
No	LPS	Density Factor	MAPE	Cost from Actual Data	Estimated Cost	Cost Difference	Bias (m3)
9	Rungkut Menanggal	355.8 kg/m3	18.98%	513,998,856	609,684,441	95,685,585	(4.92)
10	Penjaringan		22.51%	532,009,800	562,752,407	30,742,607	(1.68)
11	Klampis	302 kg/m3	17.65%	423,371,580	451,470,140	28,098,560	(1.68)
			TOTAL	**6,786,242,686**	**6,701,478,881**	**(84,763,805)**	

The table shows the total of cost differences per each region. There is a significant difference between the actual cost and the estimated cost. The most significant is in north region in which the actual cost is significantly higher than the estimated cost with total cost difference is Rp 773,177,188.93. The second most significant is in east region in which the actual cost is also higher than the estimated cost with total cost difference is Rp 84,763,804.85. While another two regions, south and central region shows that the actual cost is smaller than the estimated cost even though the cost difference is not as significant as the difference in north and east region. Table 4.7 shows the recapitulation of cost difference for each region.

Table 4. 8 Recapitulation of Cost Difference between Actual Cost and Estimated Cost in All Region

Region	Cost from Actual Data	Estimated Cost	Cost Difference
Surabaya Utara	4,168,811,192.00	3,395,634,003.07	(773,177,188.93)
Surabaya Selatan	4,255,254,555.00	4,274,606,352.80	19,351,797.80
Surabaya Pusat	5,141,188,288.00	5,147,602,478.94	6,414,190.94
Surabaya Timur	6,786,242,686.00	6,701,478,881.15	(84,763,804.85)
Total Cost Difference			**(832,175,005.04)**

The total cost difference between actual cost and estimated cost is Rp 832,175,005.04. If the best fit estimation density being analyzed from previous tabulation represents the most appropriate density as the conversion factor, then it means that DKP has gained loss within one year of observed period of time. The hypotheses is that DKP should have paid less than the actual payment because the volume being transported is supposed to be smaller than what had been recorded in the monthly certificate. While from the partner side, partners that manage transportation activity for LPS in north and east region received excessive gain because the volume of solid waste being transported by them were not too high. In contrary, partners that manage transportation activity for LPS in south and central region received loss because they were paid less for the estimated volume of solid waste that they managed.

However it is still not clear whether the estimated density taken from four previous study are still relevant or not to today`s generation of municipal solid waste in Surabaya. Even though density taken from Study DKP 2014 that is 288 kg/m^3 having the most best fit density, but due to wide range of percentage error in estimating, further tabulation and analysis must be done in order to check the relevancy.

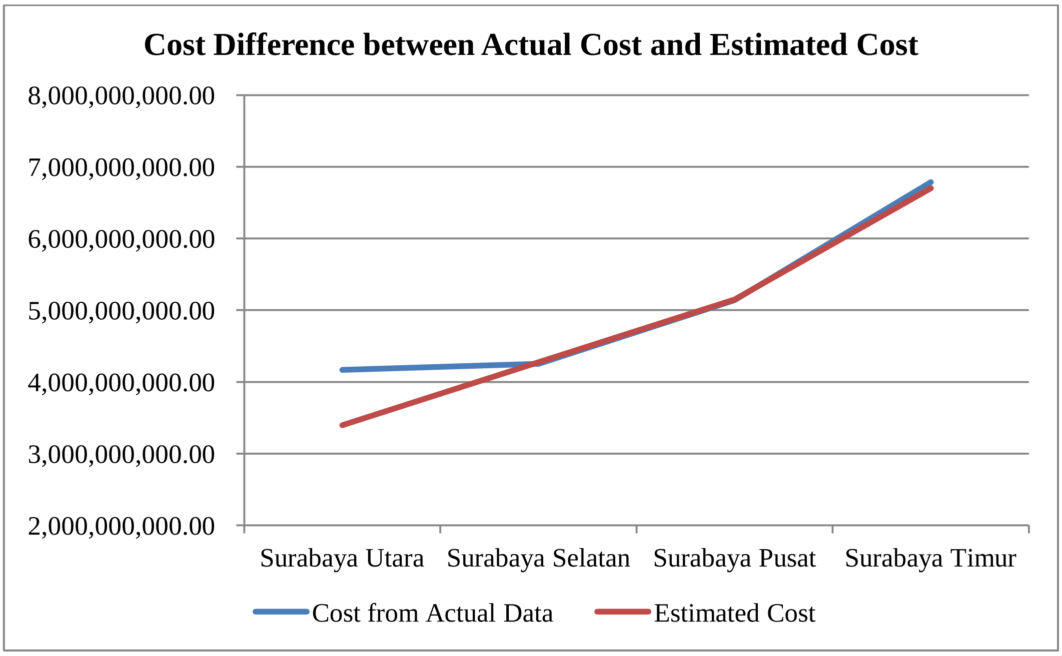

Figure 4. 8 Cost Difference between Actual Cost and Estimated Cost in All Region

The way to figure out the new density that is more appropriate to be used as the conversion factor is by checking its bias value, which can be done by trial and error. Positive bias indicates the estimation model is underestimating the actual model, therefore the density factor is reduced in order to get bias close to 0. When the density factor used in LPS Benteng is decreased by 69.5 poin from 288 kg/m^3 into becoming 218.5 kg/m^3, the bias is reduced into 0.24 and the total cost difference is reduced becoming Rp 93.604,11. Thus it can be presume that the density as conversion factor to estimate volume in LPS Benteng shows closest result to the actual model when the density used is 218.5 kg/m^3.

Table 4. 9 Comparison between Actual Transportation Cost and Estimated Transportation Cost of Solid Waste Management from LPS Benteng to TPA with New Density Factor

Month	Date	Weight (kg)	Volume (m3)			Unit Price per m3	Distance	Transportation Cost of Solid Waste			Cost Difference
			Actual Data from LPS	Estimated Volume 218.5	Volume in Contract			Cost in Contract	Cost from Actual Data	Estimated Cost	
			A1	A2	A3	B	C	D3 = A3 x B x C	D1 = A1 x B x C	D2 = A2 x B x C	E = D2 - D1
Juli 2014	1	22340	104	102	105	1,315	22	Rp 3,037,650.00	Rp 3,008,720.00	Rp 2,957,877.35	Rp (50,842.65)
	2	34190	104	156	105	1,315	22	Rp 3,037,650.00	Rp 3,008,720.00	Rp 4,526,849.89	Rp 1,518,129.89
	3	23110	102	106	105	1,315	22	Rp 3,037,650.00	Rp 2,950,860.00	Rp 3,059,827.46	Rp 108,967.46
	4	22610	102	103	105	1,315	22	Rp 3,037,650.00	Rp 2,950,860.00	Rp 2,993,626.09	Rp 42,766.09
	5	33720	108	154	105	1,315	22	Rp 3,037,650.00	Rp 3,124,440.00	Rp 4,464,620.59	Rp 1,340,180.59
	6	16510	102	76	105	1,315	22	Rp 3,037,650.00	Rp 2,950,860.00	Rp 2,185,969.34	Rp (764,890.66)
	7	23450	104	107	105	1,315	22	Rp 3,037,650.00	Rp 3,008,720.00	Rp 3,104,844.39	Rp 96,124.39
	8	35240	104	161	105	1,315	22	Rp 3,037,650.00	Rp 3,008,720.00	Rp 4,665,872.77	Rp 1,657,152.77
	9	13940	104	64	105	1,315	22	Rp 3,037,650.00	Rp 3,008,720.00	Rp 1,845,694.28	Rp (1,163,025.72)
	10	23240	102	106	105	1,315	22	Rp 3,037,650.00	Rp 2,950,860.00	Rp 3,077,039.82	Rp 126,179.82
	11	29580	104	135	105	1,315	22	Rp 3,037,650.00	Rp 3,008,720.00	Rp 3,916,473.23	Rp 907,753.23
	12	34520	102	158	105	1,315	22	Rp 3,037,650.00	Rp 2,950,860.00	Rp 4,570,542.79	Rp 1,619,682.79
	13	26770	104	123	105	1,315	22	Rp 3,037,650.00	Rp 3,008,720.00	Rp 3,544,421.51	Rp 535,701.51
	14	21810	104	100	105	1,315	22	Rp 3,037,650.00	Rp 3,008,720.00	Rp 2,887,703.89	Rp (121,016.11)
	15	33920	104	155	105	1,315	22	Rp 3,037,650.00	Rp 3,008,720.00	Rp 4,491,101.14	Rp 1,482,381.14
……..											
Juni 2015	16	18570	102	85	104	1,510	22	Rp 3,454,880.00	Rp 3,388,440.00	Rp 2,823,319.91	Rp (565,120.09)
	17	26080	104	119	104	1,510	22	Rp 3,454,880.00	Rp 3,454,880.00	Rp 3,965,114.87	Rp 510,234.87
	18	22370	102	102	104	1,510	22	Rp 3,454,880.00	Rp 3,388,440.00	Rp 3,401,059.04	Rp 12,619.04
	19	20640	102	94	104	1,510	22	Rp 3,454,880.00	Rp 3,388,440.00	Rp 3,138,035.70	Rp (250,404.30)
	20	29690	104	136	104	1,510	22	Rp 3,454,880.00	Rp 3,454,880.00	Rp 4,513,967.05	Rp 1,059,087.05
	21	26030	104	119	104	1,510	22	Rp 3,454,880.00	Rp 3,454,880.00	Rp 3,957,513.04	Rp 502,633.04
	22	22520	102	103	104	1,510	22	Rp 3,454,880.00	Rp 3,388,440.00	Rp 3,423,864.53	Rp 35,424.53
	23	24430	102	112	104	1,510	22	Rp 3,454,880.00	Rp 3,388,440.00	Rp 3,714,254.46	Rp 325,814.46
	24	19790	104	91	104	1,510	22	Rp 3,454,880.00	Rp 3,454,880.00	Rp 3,008,804.58	Rp (446,075.42)
	25	22370	102	102	104	1,510	22	Rp 3,454,880.00	Rp 3,388,440.00	Rp 3,401,059.04	Rp 12,619.04
	26	26400	106	121	104	1,510	22	Rp 3,454,880.00	Rp 3,521,320.00	Rp 4,013,766.59	Rp 492,446.59
	27	20630	102	94	104	1,510	22	Rp 3,454,880.00	Rp 3,388,440.00	Rp 3,136,515.33	Rp (251,924.67)
	28	22670	104	104	104	1,510	22	Rp 3,454,880.00	Rp 3,454,880.00	Rp 3,446,670.02	Rp (8,209.98)
	29	26330	102	121	104	1,510	22	Rp 3,454,880.00	Rp 3,388,440.00	Rp 4,003,124.03	Rp 614,684.03
	30	24400	106	112	104	1,510	22	Rp 3,454,880.00	Rp 3,521,320.00	Rp 3,709,693.36	Rp 188,373.36
								Rp 1,186,400,424.00	**Rp 1,172,309,028.00**	**Rp 1,172,215,423.89**	**Rp (93,604.11)**

Table 4.5 shows the calculation of cost difference when the weight is converted into volume using new density factor 218.5 kg/m^3. However even though the new density has been determined, but there is another problem emerged. From the explanation of DKP staff in converting the weight of solid waste into volume of solid waste, they use density taken from JICA study which is 305 kg/m^3 as the conversion factor. Looking at the example happened in LPS Benteng, it shows that there is inconsistency in using the conversion factor to determine the volume of solid waste as the basis of payment. The same calculation is also done for others LPS in order to check whether there is similar inconsistency occurred in other LPS. Table 4.6 shows the recapitulation of the new density factor used in each LPS in order to minimize the occurrence of bias.

Table 4. 10 Cost Difference between Actual Cost and Estimated Cost in LPS Region North when the New Density Factor is Used

Surabaya Utara							
No	**LPS**	**Density Factor**	**MAPE**	**Cost from Actual Data**	**Estimated Cost**	**Cost Difference**	**Bias (m3)**
1	Dupak	293 kg/m3	20.76%	273,549,056	273,683,971	134,915	(0.022)
2	Ampel	246 kg/m3	14.26%	854,384,400	854,191,562	(192,838)	0.002
3	Babaan	257.5 kg/m3	20.92%	364,541,276	364,315,470	(225,806)	0.102
4	Benteng	218.5 kg/m3	13.74%	1,172,309,028	1,172,215,42	(93,604)	0.245
5	Indrapura	218.5 kg/m3	23.17%	224,733,388	224,816,626	83,238	0.105
6	Krembangan	182.5 kg/m3	20.22%	768,182,544	768,390,292	207,748	0.343
7	Wonokusumo	359 kg/m3	16.09%	511,111,500	511,758,666	647,166	0.186
TOTAL				**4,168,811,192**	**4,169,372,01**	**560,819**	
Surabaya Selatan							
No	**LPS**	**Density Factor**	**MAPE**	**Cost from Actual Data**	**Estimated Cost**	**Cost Difference**	**Bias (m3)**
1	Joyoboyo	283 kg/m3	13.96%	876,294,900	876,470,914	176,014	(0.105)
2	Bendul Merisi	289 kg/m3	14.25%	543,546,720	543,985,858	439,138	0.056
3	Kemlaten	307.5 kg/m3	26.55%	190,978,398	190,860,016	(118,382)	0.019
4	Pagesangan	290 kg/m3	16.71%	568,940,160	568,528,980	(411,180)	0.218
5	Babadan Indah	276 kg/m3	19.35%	117,952,550	118,008,743	56,193	0.045
6	Karang Pilang	277 kg/m3	20.27%	120,791,331	120,715,308	(76,023)	0.010
7	Kebraon	299.5 kg/m3	22.29%	338,492,930	338,663,388	170,458	0.149
8	Waru Gunung I&II	264 kg/m3	52.76%	137,815,650	137,817,221	1,571	0.197

Table 4. 11 Cost Difference between Actual Cost and Estimated Cost in LPS Region North when the New Density Factor is Used (Cont`d)

No	LPS	Density Factor	MAPE	Cost from Actual Data	Estimated Cost	Cost Difference	Bias (m3)
Surabaya Selatan							
9	Bogangin	311 kg/m3	47.93%	154,987,658	155,064,642	76,984	(0.000)
10	Kembang Kuning	307 kg/m3	11.34%	1,205,454,25	1,205,429,56	(24,696)	0.027
TOTAL				**4,255,254,55**	**4,255,544,63**	**290,077**	
Surabaya Pusat							
No	**LPS**	**Density Factor**	**MAPE**	**Cost from Actual Data**	**Estimated Cost**	**Cost Difference**	**Bias (m3)**
1	Simo Lawang	289 kg/m3	16.47%	529,807,054	529,901,204	94,150	0.238
2	Penghela	261.5 kg/m3	17.75%	403,965,400	403,809,451	(155,949)	0.190
3	Pasar Kembang	299.5 kg/m3	24.63%	336,847,456	337,010,451	162,995	0.104
4	Kedondong	292.5 kg/m3	23.37%	425,752,302	425,848,619	96,317	0.036
5	Dinoyo	234 kg/m3	23.06%	418,452,424	418,491,870	39,446	0.163
6	Tambak Rejo	300 kg/m3	43.73%	2,003,562,868	2,001,988,83	(1,574,036)	(12.03)
7	Kedunganyar	405 kg/m3	14.10%	326,549,652	326,293,180	(256,472)	0.116
8	Kayoon	430 kg/m3	17.56%	291,094,752	291,016,305	(78,447)	0.230
9	Legundi	377.5 kg/m3	23.04%	405,156,380	405,129,515	(26,865)	0.289
TOTAL				**5,141,188,288**	**5,139,489,42**	**(1,698,859)**	
Surabaya Timur							
No	**LPS**	**Density Factor**	**MAPE**	**Cost from Actual Data**	**Estimated Cost**	**Cost Difference**	**Bias (m3)**
1	Kendangsari	277 kg/m3	16.62%	935,128,112	934,467,069	(661,043)	(0.051)
2	Gebang Putih	270 kg/m3	18.05%	523,975,424	523,531,529	(443,895)	0.025
3	Kutisari PLN	324.5 kg/m3	24.56%	399,327,530	399,071,566	(255,964)	0.156
4	Bratang	257.5 kg/m3	15.43%	1,173,784,222	1,173,408,65	(375,565)	0.296
5	Tenggilis M	273 kg/m3	20.94%	496,428,048	496,129,184	(298,864)	0.037
6	Rungkut Alang2	269.5 kg/m3	21.08%	774,546,564	774,134,136	(412,428)	0.050
7	Semolowaru	312 kg/m3	28.25%	481,105,088	481,089,977	(15,111)	0.004
8	Kangean	256 kg/m3	24.86%	531,318,630	530,975,364	(343,266)	0.038
9	Rungkut Menanggal	422 kg/m3	16.68%	513,998,856	514,042,000	43,144	0.211
10	Penjaringan	376.5 kg/m3	20.81%	532,009,800	531,812,235	(197,565)	0.044
11	Klampis	322 kg/m3	17.79%	423,371,580	423,428,516	56,936	0.135
TOTAL				**6,784,993,854**	**6,782,090,23**	**(2,903,619)**	

The table shows the total of cost differences per each region when the new density in each LPS is used as the conversion factor to estimate the volume of solid waste being transported. The result shows that the cost difference has significantly reduced compare to the result from previous calculation. The cost difference now is only ranged from Rp 290,076.66 to RP 2,903,6190.09 with region east as the region that has the highest cost difference. It indicates that the smaller the bias, the smaller the cost difference between actual data and the estimate cost. It also can be seen that the range of MAPE value has decreased from 15.44% to 69.83% into becoming 11.34% to 52.76%. Table 4.13 and figure 4.3 shows the recapitulation of cost difference between actual cost and estimated cost when new density is used as the conversion factor.

Table 4. 12 Recapitulation of Cost Difference between Actual Cost and Estimated Cost in All Region when the New Density is Used

Region	Cost from Actual Data	Estimated Cost	Cost Difference
Surabaya Utara	4,168,811,192.00	4,169,372,010.76	560,818.76
Surabaya Selatan	4,255,254,555.00	4,255,544,631.66	290,076.66
Surabaya Pusat	5,141,188,288.00	5,139,489,428.72	(1,698,859.28)
Surabaya Timur	6,784,993,854.00	6,782,090,234.91	(2,903,619.09)
TOTAL SELISIH			**(3,751,582.94)**

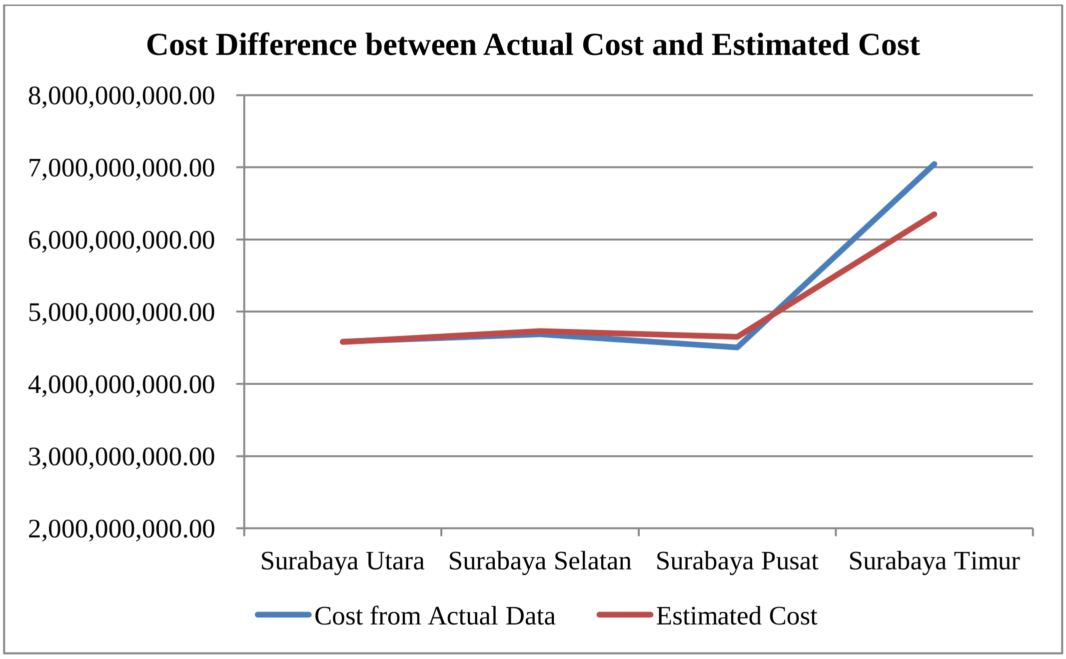

Figure 4. 9 Cost Difference between Actual Cost and Estimated Cost in All Region when the New Density is Used

The result of new density that gives smallest bias are vary from each region. The range of density in north region is ranged from 182.5 kg/m^3 to 359 kg/m^3 with median 246 kg/m^3. While the range of density in south region is ranged from 264 kg/m^3 to 307.5 kg/m^3 with median 289.5 kg/m^3. Meanwhile the range of density in central region is ranged from 234 kg/m^3 to 430 kg/m^3 with median 299.5 kg/m^3. Then the last the range of density in east region is ranged from 256 kg/m^3 to 422 kg/m^3 with median 277 kg/m^3.

Looking at this result, it can be seen that most LPS are not showing 305 kg/m^3 as their conversion factor from weight to volume of solid waste. Then it can be concluded that the conversion factor used by DKP as basis of payment to partners for solid waste transportation activity showing inconsistency and that the conversion factor is not appropriately used. Thus it is required to do direct observation in the field in order to figure out the root cause that causing the occurrence of high percentage error and the inconsistency of conversion factor used.

4.3.3 Root Cause Analysis of LPS with High Error Estimation

After conducting statistical analysis to figure out the density of solid waste in each LPS from the available historical data, the result shows that there is inconsistency in using the conversion factor to convert weight into volume of solid waste. It leads to the occurrence of high percentage error when density factor 0.305 kg/m^3 is tested using error measurement. Thus it requires to do direct observation in order to figure out the root cause and to gain better understanding about the system of solid waste management in the observed LPS.

The first step done before conducting direct observation is to determine the observed location by selecting LPS from each region that have high percentage error and high cost difference between the actual and estimation transportation cost. Table 4.9 shows the list of observed LPS from each region.

Table 4. 13 List of Observed LPS from each Region

No.	Region			
	North	Central	South	East
1.	Benteng	Dinoyo	Joyoboyo	Kutisari PLN
2.	Ampel	Tambakrejo	Kebraon	Bratang
3.	Indrapura	Kayoon	Waru Gunung	Kangean
4.	Krembangan Barat	Legundi	Kembang Kuning	Rungkut Menanggal

After selecting the location of observed LPS, the next step is to prepare the list of question which will be used during the observation. The questions made will lead to several points that the writer wants to figure out regarding the factors that affect the density of solid waste in LPS and the factors that causing high percentage error from previous statistical analysis. Table 4.10 shows the list of question that the writer has prepared before conducting the observation by following 5W+1H method.

Table 4. 14 List of Questions for Observation

Question	
What	What kinds of waste being transferred to LPS?
Who	Who gets involved in waste management activity in LPS?
Where	Where are the areas that the garbage men normally collect the waste from?
When	What time is the container in LPS normally being transported to TPA?
Why	Is there any sorting activity before the waste being transported to TPA? If yes, what kind of waste being sorted and how many percentage it can reduce the total volume?
	Is there any press machine installed in LPS?
	Is there any hotel, restaurant, or offices disposed their waste in LPS?
How	How is the transferring process of solid waste from the sources to LPS?
	How is the transportation process of solid waste from LPS to TPA?

After preparing the list of question, the observation was done in each selected LPS by interviewing the officer assigned in LPS. Table 4.11 until 4.14 shows the form used during observation as well as the answers from each column questions.

Table 4. 15 Observation Form from Observed LPS in North Region

LPS	Mixed Solid Waste Composition	Transferring and Transportation Process	Served Area	Transportation Duration	Installed Machine Press	Sorting Activity	Transportation Schedule
Benteng	Mostly is organic waste from residential and market	The garbage men unload the waste inside their garbage carts into the container put in LPS. Any recyclable materials such as bottle plastics/glass, papers, and woods are sorted and not being disposed. When the container is full, dump truck driver will pick up the full container, replace it with empty container and transport the container fulled with solid waste to TPA	The whole region of Kecamatan Semampir	1 hour	x	Yes (plastic / glass bottle, cardboard / paper, plywood / board)	06.00 / 09.00 /14.00
Ampel (divided into 2 location Camplungan dan Pegirian)	Mostly is organic waste from residential and market. The others composition are from street cleaning, tree branches crops, and construction materials.	Overall the transferring and transportation process is similar to the process in LPS Benteng. Most of the garbage men unload the solid waste in the morning or afternoon. However during night, the container is often filled with garbage from individual who disposed directly to LPS. The problem is that these individuals are not supposed to dispose their garbage there because they are not living in the nearby neighborhood. This is due to lack of control during night and the location of LPS which near the main street.	Kelurahan Sidotopo, Kecamatan Semampir	2 hour (without traffic) - 3 jam (with traffic)	x	Yes (plywood, plastic bottle, cardboard). (up to 2 Tossa per day, reducing 25% from total volume.	05.00 / 12.00 - 13.00
Indrapura	Mostly is organic waste from residential	Overall the transferring and transportation process is similar to the process in LPS Benteng. The volume inside container is rarely overcapacity nor undercapacity, mostly it is fit with the capacity of container. Because the driver will only pick up the container when it is full	Jl. Perak Timur, Jl. Indrapura	1 hour	x	yes but there are not a lot (plastic bottle, paper)	10.00

Table 4. 16 Observation Form from Observed LPS in North Region (Cont`d)

LPS	Mixed Solid Waste Composition	Transferring and Transportation Process	Served Area	Transportation Duration	Installed Machine Press	Sorting Activity	Transportation Schedule
Krembangan Barat	Mostly is organic waste from residential. The others are from tree branches crops, small medium enterprises (i.e. plywood).	Overall the transferring and transportation process is similar to the process in LPS Benteng. The overcapacity is often occur during the early of weekdays (Monday-Wednesday) because there are many garbage men working. The undercapacity is often occur during weekend because some garbage men are off from work.	Krembangan Barat, Krembangan Selatan, Krembangan Baru, Parangkusumo, Kantor DPR sampai Jl Rajawali	1 hour (morning), > 1 hour (afternoon)	x	yes (plastic bottle, white paper and thick papers)	03.30 / 07.00 / 13.00 - 14.00

Table 4. 17 Observation Form from Observed LPS in Central Region

LPS	Mixed Solid Waste Composition	Transferring and Transportation Process	Served Area	Transportation Duration	Installed Machine Press	Sorting Activity	Transportation Schedule
Dinoyo	Mostly is organic waste from residential. The others from offices are being sorted	Overall the transferring and transportation process is similar to the process in LPS Benteng. However for garbage men who collect waste from offices which normally consists of paper, plastic and cardboard, they will unload directly to sorting area. The volume of solid waste inside container is increasing every year. The officer in LPS steps on the solid waste inside container to	Kelurahan Keputran	1-2 hour	x	Yes (plastic, papers, cardboard, cans) reducing 30%	08.00 / 12.00

Table 4. 18 Observation Form from Observed LPS in Central Region (Cont`d)

LPS	Mixed Solid Waste Composition	Transferring and Transportation Process	Served Area	Transportation Duration	Installed Machine Press	Sorting Activity	Transportation Schedule
Tambakrejo	Mostly is organic waste from residential and market. The others composition are from street cleaning, tree branches crops	The garbage men unload the waste inside their garbage carts into the press machine inside in LPS Tambakrejo. Only organic waste, papers, plastics are allowed to be loaded. Garbage such as woods, sponge, mattress / bed, are not allowed, instead they will be sorted. The recycable items will not be disposed, the non recycable items will be disposed directly to container without being pressed first. The lyeachate resulted from pressing process will be processed thus the liquid composition inside mix solid waste is reduced.	Kelurahan Tambakrejo	1 hour	v	Yes (papers, woods, plastic bottle)	05.30 / 08.00
Kayoon	Mostly is organic waste from residential. The others from hotel, restaurant and flowers market are being processed	During observation, LPS Kayoon is no longer served by partners. Instead, dump truck from DKP pick up the waste and transport it to TPA. Regarding garbage from restaurant and hotel (such as Hyatt, Sahid, Hotell 88), they are being separated to be sold and processed for livestock food. While garbage from flowers market are being processed for fertilizer.	Kayoon (restaurants, hotel, flowers market)	1 hour	x	Yes (food excess)	
Legundi	Mostly is organic waste from residential. The others are from schools, restaurants, café.	Overall the transferring and transportation process is similar to the process in LPS Benteng. The overcapacity is often occured during early of month because the garbage men works more intense due to the salary payment period, while undercapacity is often occured during the end of month. The surface is often liled up when there	Kelurahan Ketabang	1 - 1.5 hour	x	Yes (carboard, papers, plastic bottle)	06.00 - 07.00 / 09.00

Table 4. 19 Observation Form from Observed LPS in South Region

LPS	Mixed Solid Waste Composition	Transferring and Transportation Process	Served Area	Transportation Duration	Installed Machine Press	Sorting Activity	Transportation Schedule
Joyoboyo	Mostly is organic waste from residential. The others from road sweeping, offices and bus station	Overall the transferring and transportation process is similar to the process in LPS Benteng. However during observation, partner is no longer transporting solid waste from this LPS. The transportation process is done by DKP since 4 months ago.	Kelurahan Sawunggaling, Sampah pasar Wonogiri, Sampah pasar gunungsari	1 - 1.5 hour	x	Yes (plastic, paper, bottle, board). Reducing 10%	06.00 / 10.00 / 13.00 / 15.00
Kebraon	Mostly is organic waste from residential and market. The others composition are from retail stores, small food stalls	Overall the transferring and transportation process is similar to the process in LPS Benteng. Garbage collected from retails store is up to 5 big pouch but most of them are sorted to be recycled.	Kelurahan Kebraon	1.5 - 2 hour	x	Yes (plastic bottle, mineral water packaging, papers, cardboard, glass bottle)	06.00 - 06.30 / 13.00

Table 4. 20 Observation Form from Observed LPS in South Region (Cont`d)

LPS	Mixed Solid Waste Composition	Transferring and Transportation Process	Served Area	Transportation Duration	Installed Machine Press	Sorting Activity	Transportation Schedule
Waru Gunung	Mostly is organic waste from residential.	Overall the transferring and transportation process is similar to the process in LPS Benteng. However during observation, partner is no longer transporting solid waste from this LPS. The transportation process is done by DKP since 2016. Previously when transportation is done by partners, the transportation is often late. Even after it is now served by DKP, the waste is still often late being transported. In 2014, RW 2 was implementing Bank Sampah program to reduce volume of solid waste. But it is now stopped due to some problems with operational cost. There are other RW whose the residents often dispose their garbage in the open empty space.	Kelurahan Waru Gunung RW 1 - 3	1.5 - 2 hour	x	Yes, (plastic bottle, tin can)	uncertain
Kembang Kuning	Mostly is organic waste from residential and market. The others are from small food stalls or restaurants	Overall the transferring and transportation process is similar to the process in LPS Benteng. The overcapacity is often occured due to the lateness of transportation schedule. This happen because there is trouble with the truck, traffic, or long queue in TPA.	Kelurahan Sawahan	1 hour	x	Yes (plastic, papers, carboard, tincan). Reducing 10 %	07.00 (2 container) / 13.00 (2 container)

Table 4. 21 Observation Form from Observed LPS in East Region

LPS	Mixed Solid Waste Composition	Transferring and Transportation Process	Served Area	Transportation Duration	Installed Machine Press	Sorting Activity	Transportation Schedule
Kutisari PLN	Mostly is organic waste from residential.	Overall the transferring and transportation process is similar to the process in LPS Benteng. The overcapacity is occurred if there is lateness in the transportation schedule. This is usually happen when TPA is flooding, especially during rainy season, which causing long queue in disposing process.	Kutisari Residential	1.5 hour	x	Yes (plastic, papers)	03.30 - 04.00 / 07.00
Bratang	Mostly is organic waste from residential and market. The others are from small food stalls or restaurants	Overall the transferring and transportation process is similar to the process in LPS Benteng. Even though LPS Bratang is located nearby Kebun Bibit park, but the garbage from the park is collected by specialized dump truck and disposed directly to TPA.	2 kecamatan (Gubeng dan Sukolilo)	1 hour (without traffic)	x	Yes (Plastics, bottle, papers). Reducing up to 10%	06.00 - 06.30 / 10.00 / 12.00 - 13.00
Kangean	Mostly is organic waste from residential. The others are from restaurants and hospital	Overall the transferring and transportation process is similar to the process in LPS Benteng. Even though there are many incoming garbage from restaurants, but most recyable items are sorted and not being disposed. While the garbage from hospitals are being separated already from the chemical waste	Kecamatan Gubeng	1 - 1.5 hour (without traffic). 2 hour (traffic)	x	Yes (papers, plastics, bottle)	05.00 (tidak tentu).
Rungkut Menanggal	Mostly is organic waste from residential and market.	Overall the transferring and transportation process is similar to the process in LPS Benteng. Garbage from tree branches cropping are disposed directly to rumah kompos. The overcapacity is often occurred during rainy season	Kelurahan Rungkut Menanggal	2.5 hour (without traffic), 3 hour (traffic)	x	Yes (bottle, plastics, papers)	05.00 / 08.00

After collecting information in the selected LPS, the next step is to analyze the result in order to figure out the cause of high error percentage and gain better understanding about the solid waste management system in LPS. There are four main points to highlight the result of this observation.

1. Composition of solid waste in every LPS is similar which is dominated by residential waste (most are the type of waste from cooking activity). When looking at the first result of statistical analysis in determining the best fit estimated density in LPS, the estimated density in 37 observed LPS is ranged from 182.5 kg/m^3 to 422 kg/m^3. It is presumed that LPS with small density indicates that there are more inorganic solid waste (plastic, bottle, cardboard, papers) with small amount of organic solid waste being disposed in there. Because inorganic solid wastes generally take more space and have bigger volume than organic solid waste, while the weight tends to be smaller than organic solid waste. For the LPS with big density, it is presumed that there is more organic solid waste with small amount of inorganic solid waste being disposed there. Because organic solid waste generally take less space especially with its compacted characteristics after being stored in a long time and have less volume than inorganic solid waste, while the weight tends to be heavier than inorganic solid waste.

   However after observing the composition of solid waste in LPS, all of them are actually having similar composition, which is dominated by residential waste. Thus the hypothesis that the composition between inorganic and organic solid waste in LPS is causing significant difference in the density value is incorrect.

Figure 4. 10 Composition of Solid Waste in LPS Ampel

Figure 4. 11 Composition of Solid Waste in LPS Kutisari PLN

2. Most of inorganic solid wastes such as glasses, papers, bottles, cardboards are being sorted by garbage men and scavengers so that there is small amount of inorganic solid waste being disposed to container. The similarity of solid waste composition is actually happen because of this activity. Due to economical value of the recyclable garbage, there is always sorting activity in LPS and it has reduced the volume of solid waste collected in there.

Figure 4. 12 Sorted Plastics and Bottles Garbage in LPS Kebraon

Figure 4. 13 Sorted Cardboard Garbage in LPS Dinoyo

3. When the volume of solid waste inside container reaches maximum capacity, usually there will be partner staff who will step on the solid waste to reduce its volume so that the wastes become more compacted. The more waste to be loaded, the more compaction needed in order to maximize the container capacity. This compaction factor becomes one of the factors that causing significant difference in the density of solid waste in LPS.

Figure 4. 14 Men Stepping on the Solid Waste Container in LPS Kembang Kuning

Figure 4. 15 Men Stepping on the Solid Waste Container in LPS Ampel

4. Another source of solid waste in LPS is also coming from market, restaurants, retail stores and office building. Even though these sources do not contribute as much as residential areas in generating the amount of solid waste, but the differences in the number of these additional sources in each LPS causing quite significant difference in the density of solid waste in LPS. LPS which located in the multi activities neighborhood will tend to generate more amount of solid waste. For example in LPS Kembang Kuning which located nearby residential areas, market, office

building, and restaurant have high amount of solid waste generation compare to LPS Indrapura which located nearby residential only.

Figure 4. 16 Solid Waste from Restaurant in LPS Kutisari PLN

Figure 4. 17 Solid Waste from Market in LPS Kembang Kuning

Looking at the four points which highlight the result of the observation, it can be concluded that the composition between inorganic and organic solid waste in LPS is causing significant difference in the density value is incorrect. The difference in the value of solid waste density is actually caused by the different amount of solid waste generation in each LPS. The amount of solid waste generation itself is depend on the sources area of solid waste, the activities and public places located nearby LPS. Regarding the historical data used in previous statistical analysis, there was high inaccuracy in the data record. After looking thoroughly in the data recording process, it was found that when the volume is increasing significantly, the weight is not significantly increased, in some data the weight in even decreasing. It is then being clarified that the recording of weight in TPA during period 2014 tends to have high error because the system was in its early implementation. So that there is a tendency of human error in inputting the weight data taken from weighbridge into the system.

4.4 Comparison of Alternatives

From the explanation of each alternative method provided in subchapter 4.1 to 4.3, the next step is to compare each alternative by analyzing its benefits and constraints. Table 4.14 presents the analysis which will be used as consideration to select the most appropriate method.

Table 4. 22 Comparison of Alternatives

	Benefits	Constraints
Alternative 1	1. Obtaining ease in measuring weight of solid waste in LPS 2. Obtaining more accurate weight measurement 3. Understanding the factors that causing the difference of weight loss during transportation process	1. The experiment can not be executed without a proper equipment, which is portable truck scale. 2. The experiment involves additional personnel to help and to assist.
Alternative 2	1. Reducing the disparity of solid waste density in LPS 2. Supporting the waste separation process from sources until the waste being disposed to landfill 3. Maximizing the economical value of waste separation process	1. The investment cost to implement this method is very high because it requires re-design of existing dump container and there is also social investment cost to educate and socializing the method 2. The cost consequence may lead to the investment of separated cart container used by garbage men to collect waste from source to LPS.

Table 4. 23 Comparison of Alternatives (Cont`d)

	Benefits	Constraints
Alternative 3	1. Obtaining estimation of solid waste density in the overall area in Surabaya 2. Obtaining cluster area based on the type of solid waste generation	1. With the dynamic change of demography and spatial condition in LPS neighborhood area, requires periodical review of estimated density to confirm its relevancy 2. The inaccuracy of historical data increase the error and inaccuracy in the result of statistical analysis

4.5 Selection of The Most Appropriate Method

After comparing benefits and constraints from each alternative method, the next step is to select the most appropriate method that will define the following process of completing this research. The selection itself was conducted by forum group discussion which done with the experts from Dinas Kebersihan dan Pertamanan. The result was that the most appropriate method to select is alternative 1, the on-site weight scaling experiment. This method is chosen because it enables to figure out the amount of weight loss during transportation process of solid waste from LPS to TPA. This method also enables to analyze the factors that causing the difference of weight loss by controlling the experiment variables. By having the range of weight loss occurred during the trip from LPS to TPA, DKP can use this information to define the weight amount of solid waste being transported from LPS. Thus the new model of payment will be suggested by changing the business model into using the weight measured from the weighbridge in TPA and being added with the weight loss taken from the experiment result to determine the total transportation cost per km per kg.

As it is mentioned in the description of alternative 1, the experiment requires proper equipment to gain accurate result as it is expected. The chosen equipment to use in this experiment is portable truck scale. Since DKP does not have this equipment in their inventory, thus the purchase of this equipment is needed. But due to its high price which up to Rp 100.000.000,00 for one item, DKP found its difficult to purchase the equipment because there is no sufficient budget to purchase it. Even though it is still possible to add the purchase requirement in the next budgeting, but due to the limitation of project timeline, this alternative is unable to be implemented as well in this research. Therefore the idea to generate possible alternative is made and the result is coming up with designing segregated truck container for the dump vehicle to reduce the disparity of solid waste in LPS.

Another way to figure out the more accurate density of solid waste to estimate its weight in LPS is by separating the composition of its mixed waste. Density of specific waste type tends to be similar if the variable of storage volume is controlled. However the existing dump container consists only one storage, thus this method will require the re-design of dump container into segregated truck container to provide storage of separated waste. The process of re-designing dump container itself requires thorough analysis of the compartment dimension, the components specification and the cost calculation of the overall required budget to invest. Another cost components as the consequences of implementing this new model of vehicle is the education and socialization towards the waste separation activities.

Considering the investment cost incurred to implement the method, alternative 2 was consider as not a practical method to choose for the project case. Even though by conducting alternative 2 the disparity of solid waste density can be reduced and it may lead to long term social and economical benefits, but due to the project timeline given to the implementation of this study, it is decided that alternative 2 will not be used for this research. However it is recommended that the study to redesign segregated waste vehicles is conducted in the future.

Therefore the method to analyze the historical data using statistical analysis was considered as well to be used for the project case. By calculating the correlation between the weight and volume of solid waste taken from the historical data in one year period, the range of possible solid waste density was examined to confirm which one has the best fit estimation. After thoroughly calculating and comparing the error measurement of the estimation factor, the result shows that the overall LPS have wide disparity of density. Thus if a single density factor is used to estimate the solid waste generation in LPS, it will lead to wide deviation of estimation result. However due to the lack of accuracy in the historical data gathered from DKP database, the data is not recommended to use as the analysis. The more accurate data of volume and weight of solid waste need to be prepared to obtain the more accurate value of density which will be used as the conversion factor.

Considering all the possibility and constraint from alternative 3, the final determination of method to use in this research is come up with hybrid method, between alternative 3 and 1. Statistical analysis using zoning method will be used to figure out the range of solid waste density in LPS by dividing the objected LPS into cluster which have similar characteristics in generating the amount of solid waste. It is presumed that the LPS with similar characteristics of neighbors tend to have the similar amount of solid waste generated. Thus the disparity of density can be reduced depend on the cluster result. In order to accommodate the method mentioned in alternative 1, another technique of experiment is generated to figure out the amount of weight loss occurred during the transportation from LPS to TPA. Then this factor will be used as the input to determine the conversion factor that will affect the amount of solid waste density in LPS.

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CHAPTER V
SELECTION OF SAMPLING LOCATION

This chapter consists of the sequence in determining sampling location to conduct the experiment. The sequence consists of selection criteria determination, weight calculation criteria, LPS database formulation, LPS characteristics assessment, and LPS clustering. The sampling location is selected based on the result of the cluster.

5.1 Determination of Selection Criteria

Density of solid waste collected in LPS differs from one another due to some factors. These factors are known from direct observation which the result is mentioned in chapter 4. The main factor that causes the difference is the amount of solid waste generation in each LPS. The more solid waste generated in LPS neighborhood area, the higher density value of solid waste collected in that LPS.

5.1.1 Selection Criteria

The selection criteria are structured using the decision hierarchy from the top with the goal decision is to determine the amount of solid waste generation in LPS. Then there are some criteria that affect the goal decision. Based on the observation in the field and discussion done with the expert from DKP, there are four criteria used to define the amount of solid waste generated in LPS, which are population density in LPS neighborhood area, economy level in LPS neighborhood area, ease of accessibility, and the availability of solid waste sources nearby LPS. The following are the explanation of each criteria that affect the amount of solid waste generation in LPS.

1. Population Density in LPS Neighborhood Area

Population density affects the amount of solid waste generation because the more people living in LPS neighborhood, it is likely that the more solid waste will be produced. The function of LPS itself is to serve the transfer station for solid waste collection from sources before being transported to the end disposal site TPA. Its main function is to facilitate the residential areas. If the LPS is located near to dense residential areas, then it is more likely that there is more solid waste generated. Population density criteria is divided into three sub criteria which are:

a. High population density,
b. Moderate population density
c. Low population density.

2. Economy Level in LPS Neighborhood Area

Economy level affects the amount of solid waste generation because higher economy level generally produces more inorganic solid waste such as tin, paper, plastic, etc. While lower economy level generally produces more organic solid waste such as the excessive cooking ingredients. With different economy level in neighborhood area, the type of solid waste composition collected in LPS will differ from one another. Economy level criteria is divided into three sub criteria which are:

a. High income residents
b. Middle income residents
c. Low income residents/slum area.

3. Ease of Accessibility

Ease of accessibility affects the amount of solid waste generation because people are more likely to dispose their garbage directly to LPS if it is located nearby main streets or having easy accessibility for them to travel to LPS. Even though it is actually not allowed for people to directly disposed to LPS (without the help of garbage men), but due to lack of control in LPS, this thing is still occurred in some LPS, especially during night time or dawn. However this criteria is affected by social behavior of people in the LPS neighborhood area. The reason that drives this social behavior is that there are some people who are unwilling to pay for garbage collection contribution fee. Thus they tend to carry their own garbage and travel to LPS which easy to be accessed while they travel to work. Ease of accessibility is divided into three sub criteria which are:

a. High accessibility
b. Moderate accessibility
c. Low accessibility

4. The Availability of Solid Waste Sources in LPS Neighborhood Area

Sources of solid waste affect the amount of solid waste generation because the more categories of sources available in LPS neighborhood area, the more amount of solid waste generated in that LPS. Even though solid waste collected in LPS is generally dominated from residential areas, but other sources like offices, stores, schools, etc. are also having possibility to dispose their garbage in the nearby LPS. This criteria is also used to support the first criteria because the sources that affect the amount of solid waste generation is not solely come from residential area. Thus having this criteria in the selection decision hierarchy is necessary. The source of solid waste criteria is divided into several sub criteria, which are:

a. Stores solid waste
b. Market solid waste
c. Restaurant/café/food stalls solid waste
d. Tourist places solid waste
e. Office solid waste
f. School solid waste
g. Hotel solid waste
h. Road sweeping solid waste
i. Worship places solid waste
j. Bus station / railway station solid waste
k. Hospital solid waste

5.1.2 Weight Determination of Selection Criteria using Analytical Hierarchy Process

The criteria that affect the amount of a solid waste generation in LPS have been determined and the next sequence is to construct a set of pairwise comparison matrices. The matrices are constructed using Expert Choice software by giving the importance score of each criteria. The score is given through FGD with the official staffs of DKP. The importance score is used to determine the level of each criteria in affecting the amount of solid waste generation. Expert Choice is used as the supporting software that facilitate decision making analysis in a more efficient, analytical and justifiable way. Figure 5.1 until figure 5.5 present the weighing result of solid waste generation criteria.

Figure 5. 1 The Weight Result of Solid Waste Generation Criteria

Figure 5. 2 The Weight Result of Solid Waste Generation Criteria – Population Density Factor

Figure 5. 3 The Weight Result of Solid Waste Generation Criteria – Economy Level Factor

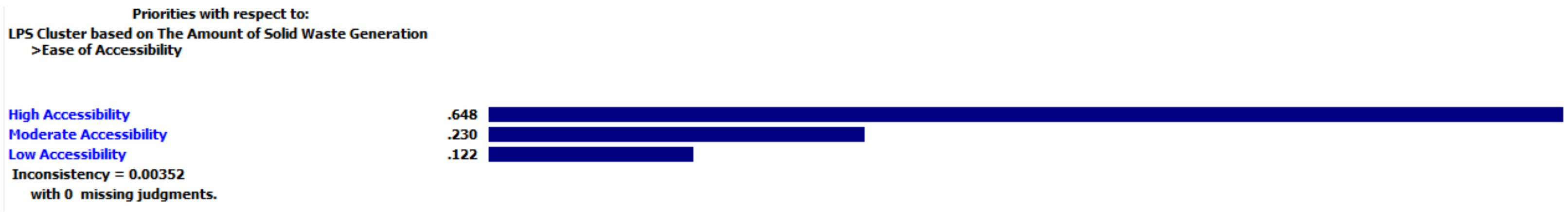

Figure 5. 4 The Weight Result of Solid Waste Generation Criteria – Ease of Accessibility Factor

Figure 5. 5 The Weight Result of Solid Waste Generation Criteria – Solid Waste Sources Factor

According to the weighing result from Expert Choice, it is known that the criteria having the most weight as the factor that affect the amount of solid waste generation in LPS is the population density. The result if followed by economy level, availability of solid waste sources and ease of accessibility. The result of each matrix is validated by checking its inconsistency value. The result is acceptable if the inconsistency value is less than or equal to 0.1. All the matrices show the inconsistency value is ≤ 0.1 thus it can be concluded that the results are acceptable. Comprehensive explanation on the weight result of each criteria and sub criteria is written as follow:

1. Population density in the LPS neighborhood area

Population density has the highest weight score among the other criteria with the score is 0.649. This criteria is considered having the most influence in the amount of solid waste generation in the LPS. It is due to the composition of solid waste in LPS is dominated by residential waste which are produced by population living nearby LPS. The population density is divided into three categories which are high population density, moderate population density and low population density. The highest weight score is the category high population density. It means that the higher the population density living nearby LPS, the more solid waste generated in there.

2. Economy level in the LPS neighborhood area

Economy level is in the second rank of the weight score after population density with the score is 0.177. The economy level in this term is justified by the income of the residents living nearby LPS area. The level of income affects the generation of solid waste because it drives people to consume goods and tend to produce more garbage. The economy level is divided into three categories which are high income residents, middle income residents and low income residents. The highest weight score is the category middle income residents, while the second place is the category low income residents and the third place is the category high income residents. The weight is given by considering that people with medium income tends to have higher purchasing power than people with low income. Thus they have sufficient financial resource to consume goods and foods and in the end there will be more daily garbage produced. While for high income residents, they are considered to be the least affecting the amount of solid waste generation in LPS. High income residents tend to produce more inorganic solid waste which will be sorted and separated by scavengers or garbage men for their economical value. While for the type of waste produced from cooking activity, high income residents tend to have meals outside their home or ordered so that there is not much of organic solid waste produced.

3. The ease of accessibility

The ease of accessibility is in the last rank of the weight score among the other criteria with the score is 0.067. This criteria has the relation with LPS location. If the LPS location is in the main streets and there is high activity of people passing by, then it is likely that this LPS generate more solid waste. However this criteria has the least importance score compare to other criteria because the garbage disposed by people who passing by the LPS is rarely found in big amount. The ease of accessibility is divided into three categories which are high accessibility, moderate accessibility and low accessibility. It means that the LPS located in the site that is easy to access by vehicles and having high frequency of people passing by, will generate more solid waste compare to other categories.

4. The availability of solid waste sources

The availability of solid waste sources is in the third rank of the weight score after economy level with the score is 0.107. Even though solid waste collected in LPS is generally dominated from residential areas, but other sources like offices, stores, schools, etc. are also having possibility to dispose their garbage in the nearby LPS. However its importance score is less than population density and economic value because not all of these non residential sources are disposing their garbage in LPS. Most of the amount of solid waste is still generated by residential areas. But it is presumed that the LPS which having more type of solid waste sources in its neighborhood area will generates more solid waste compare to LPS which having less type of solid waste sources. The solid waste sources is divided into 11 categories which are stores, market, restaurant/café/food stalls, tourist places, office, school, hotel, road sweeping, worship place, bus station/railway station and hospital. Among these 11 categories, market has the highest weight score in solid waste sources criteria because market tends to dispose more amount of solid waste compare to other non-residential sources. The waste of most markets (registered as non PD Surya market) is normally collected by garbage men to be transferred to LPS. The next rank is restaurant/café/food stalls because the waste they dispose generally is excessive food or ingredients which considered as organics solid waste. This type of waste having less economical value thus the garbage men will tend to directly dispose them to dump container in LPS.

After obtaining the weight for each criteria and sub criteria of AHP to determine the characteristics of LPS solid waste generation, the next is to do the calculation of each characteristic score. The equation used to do this assessment is as following:

LPS Characteristics Score = (A1xA) + (A2xA) + (A3xA) + (B1xB) + (B2xB) + (B3xB) + (C1xC) + (C2xC) + (C3xC) + (D1xD) + (D2xD) + (D3xD) + (D4xD) + (D5xD) + (D6xD) + (D7xD) + (D8xD) + (D9xD) + (D10xD) + (D11xD) ………(5.1)

The explanation of each code along with its score is provided in following table:

Table 5. 1 LPS Solid Waste Generation Score

Code	Criteria	Weight
A	Population Density	0.649
A1	Low Population Density	0.105
A2	Moderate Population Density	0.258
A3	High Population Density	0.637
B	Economy Level	0.177
B1	High Income Residents	0.105
B2	Middle Income Residents	0.637
B3	Low Income Residents	0.258
C	Ease of Accessibility	0.067
C1	High Accessibility	0.648
C2	Moderate Accessibility	0.230
C3	Low Accessibility	0.122
D	Source of Solid Waste	0.107
D1	Stores	0.084
D2	Market	0.235
D3	Restaurant/Café/Food Stalls	0.156
D4	Tourist Places	0.144
D5	Office	0.042
D6	School	0.037
D7	Hotel	0.116
D8	Road Sweeping	0.023
D9	Worship Place	0.019

Table 5. 2 LPS Solid Waste Generation Score (Cont`d)

Code	Criteria	Weight
D10	Bus Station / Railway Station	0.092
D11	Hospital	0.053

5.2 Assessment of LPS Characteristics

After obtaining the weight score of each criteria and sub criteria for determining LPS characteristics, the next step is to establish database consist of the characteristic from each LPS. At the beginning of the project, it was known that there would be 37 LPS as the research objects whom its solid waste transportation activity is done by partners. But during the execution of the project, DKP purchased more compactor trucks and as the consequences there are reducing number of LPS that is managed under partnership. There are total 9 LPS which already served by DKP compactor and dump trucks. Thus for the following execution of the research, especially regarding with the sampling and experiment, the objects are reduced into 28 remaining LPS. Those 9 reduced LPS are LPS Bratang, LPS Kangean, LPS Penjaringan Sari, LPS Joyoboyo, LPS Waru Gunung I&II, LPS Legundi, LPS Kayoon, LPS Kedung Anyar, and LPS Pasar Kembang.

5.2.1 Database Formulation of LPS Characteristics

To complete the selection of sampling location according to the cluster of similar characteristics, a database consist of the information regarding the LPS category is established.

1. Population Density in LPS Neighborhood Area

The first database is regarding the population density in LPS neighborhood area. The related data used is the list of garbage sources collected by garbage men from surrounded RW. This data is available in DKP branch office for each region and representative staffs from DKP are assigned to update this data annually. While the data used in this research is taken from 2015 data. The total number of RW disposing their garbage in each LPS is known then the density population is known by observing the surrounded area. Data taken from Bappeko related to the number of population in each Kelurahan is also used to support the determination. The neighborhood area of particular LPS is considered high if there are many RW disposing there and the average of population per RW is high. Moderate category of population density is given if there are many RW disposing in particular LPS but the average of population per RW is not too high. While low category is given if there are few RW disposing there and the average of population per RW is low. Table 5.2 shows the database of population density in LPS neighborhood area.

Table 5. 3 Category of Population Density in LPS Neighborhood Area

No	LPS	Kelurahan	Total RW	Category
North Surabaya				
1	Wonokusumo Kidul	Wonokusumo	4	Moderate
2	Dupak Bangunsari	Dupak	2	Low
3	Krembangan Barat	Krembangan Selatan	10	Moderate
4	Benteng	Ampel	7	High
		Ujung	5	
		Pegirian	3	
		Sidotopo	2	
		Perak Timur	3	
		Nyamplungan	4	
5	Indrapura	Krembangan Utara	3	Moderate
		Perak Timur	5	
6	Babaan	Krembangan Utara	5	Low
7	Ampel	Ampel	5	Moderate
		Pegirian	4	
East Surabaya				
No	**LPS**	**Kelurahan**	**Total RW**	**Category**
1	Semolowaru	Klampis Ngasem	1	Moderate
		Semolowaru	7	
		Medokan Semampir	1	
2	Klampis Ngasem	Klampis Ngasem	7	Low
3	Gebang Putih	Gebang Putih	5	Moderate
		Manyar Sabrangan	2	
4	Kendangsari	Kendangsari	4	High
5	Kutisari PLN	Kutisari	6	Low
6	Tenggilis Mejoyo	Tenggilis Mejoyo	4	Moderate
7	Rungkut Alang-Alang	Kalirungkut	6	Moderate
		Rungkut Kidul	2	
8	Rungkut Menanggal	Gunung Anyar	4	Moderate
		Rungkut Menanggal	4	
South Surabaya				
No	**LPS**	**Kelurahan**	**Total RW**	**Category**
1	Kembang Kuning	Pakis	9	High

Table 5. 4 Category of Population Density in LPS Neighborhood Area (Cont`d)

South Surabaya				
No	**LPS**	**Kelurahan**	**Total RW**	**Category**
2	Bendul Merisi	Bendul Merisi	10	Moderate
3	Bogangin	Kedurus	2	Low
4	Kemlaten	Kebraon	4	Low
5	Kebraon	Kebraon	8	Moderate
6	Karangpilang Marinir	Karangpilang	3	Low
7	Babatan Indah	Babatan	4	Low
8	Pagesangan	Pagesangan	4	Moderate
Central Surabaya				
No	**LPS**	**Kelurahan**	**Total RW**	**Category**
1	Penghela	Peneleh	1	Moderate
		Gundih	3	
		Bubutan	2	
		Tembok Dukuh	1	
		Wonorejo	1	
		Jepara	2	
2	Simolawang	Gading	1	Moderate
		Simolawang	8	
		Sidodadi	4	
		Simokerto	5	
3	Tambakrejo	Kapasan	2	High
		Gading	11	
		Ploso	2	
		Tanah Kali Kedinding	1	
		Rangkah	3	
		Tambakrejo	4	
		Simokerto	4	
4	Dinoyo	Keputran	6	Moderate
		Wonorejo	1	
5	Kedondong	Tegalsari	7	Moderate
		Wonorejo	2	

2. Economy Level in LPS Neighborhood Area and Ease of Accessibility

The second database is regarding the economy level in LPS neighborhood area and the ease of accessibility of the LPS location. Observation in the neighborhood area of each LPS is done to define the category of economy level from residents living in surrounded LPS. Due to the lack of data related to household income per RW, thus subjective judgment is used. The area consist of permanent house and dominated with big size house are considered as high income residents. The area consists of mix between permanent and non permanent house and dominated with medium size house are considered as middle income residents. While the area dominated with non permanent house or living in slum area are considered as low income residents.

Determination of ease of accessibility is done by observing the location of LPS. If the LPS is located on the main road with high access of mobility such as in , then it is considered as high accessibility. If the LPS is located on the road with moderate access of mobility then it is considered as moderate accessibility. While for the LPS that is located far from main road and having low access of mobility then it is considered as low accessibility. Table 5.3 shows the database of economic level and the ease of accessibility in LPS neighborhood area

Table 5. 5 Category of Economic Level and Ease of Accessibility in LPS Neighborhood Area

North Region		Economic Level			Ease of Accessibility		
No	LPS	High Income Resident	Middle Income Resident	Low Income Resident	High	Moderate	Low
1	Wonokusumo Kidul	0	1	1	0	1	0
2	Dupak Bangunsari	0	1	0	0	1	0
3	Krembangan Barat	0	1	0	0	1	0
4	Benteng	0	1	1	0	1	0
5	Indrapura	0	0	1	0	1	0
6	Babaan	0	1	1	0	1	0
7	Ampel	0	1	0	1	0	0
East Region		**Economic Level**			**Ease of Accessibility**		
No	LPS	High Income Resident	Middle Income Resident	Low Income Resident	High	Moderate	Low
1	Semolowaru	0	1	0	0	0	1
2	Klampis Ngasem	1	1	0	1	0	0
3	Gebang Putih	0	1	0	0	1	0
4	Kendangsari	1	1	0	0	0	1
5	Kutisari PLN	1	1	0	0	1	0
6	Tenggilis Mejoyo	1	1	0	1	0	0
7	Rungkut Alang2	1	1	0	1	0	0
8	Rungkut Menanggal	0	1	0	0	0	1

Table 5. 6 Category of Economic Level and Ease of Accessibility in LPS Neighborhood Area (Cont`d)

South Region		Economic Level			Ease of Accessibility		
No	LPS	High Income Resident	Middle Income Resident	Low Income Resident	High	Moderate	Low
1	Kembang Kuning	1	1	1	0	1	0
2	Bendul Merisi	0	1	1	0	1	0
3	Bogangin	0	1	0	0	1	0
4	Kemlaten	0	0	1	0	0	1
5	Kebraon	0	0	1	0	0	1
6	Karangpilang Marinir	0	1	0	0	1	0
7	Babatan Indah	1	1	0	0	0	1
8	Pagesangan	1	1	0	0	1	0
Central Region		**Economic Level**			**Ease of Accessibility**		
No	LPS	High Income Resident	Middle Income Resident	Low Income Resident	High	Moderate	Low
1	Penghela	0	1	1	0	1	0
2	Simolawang	0	1	1	1	0	0
3	Tambakrejo	1	1	1	1	0	0
4	Dinoyo	0	1	0	0	1	0
5	Kedondong	1	1	0	0	1	0

3. Sources of Solid Waste

The third database is regarding the sources of solid waste available in the LPS neighborhood area. Observation in the neighborhood area of each LPS is done to define whether the type of sources is available or not. Table 5.4 shows the database of the availability of solid waste sources in LPS neighborhood area.

Table 5. 7 Category of Solid Waste Sources in LPS Neighborhood Area

North Region												
No	LPS	Shops	Market	Restaurant / Café / Food Stalls	Tourist Place	Office	School	Hotel	Road Sweeping	Worship Place	Bus Station / Railway Station	Hospital
1	Wonokusumo Kidul	1	1	0	0	0	1	0	0	1	0	1
2	Dupak Bangunsari	1	1	0	0	0	1	1	1	1	0	1
3	Krembangan Barat	1	1	0	1	1	1	1	1	1	0	1
4	Benteng	1	1	1	0	0	1	1	1	1	0	1
5	Indrapura	1	0	0	0	1	1	0	1	1	0	0
6	Babaan	1	1	1	0	0	1	0	0	1	0	1
East Region												
No	LPS	Shops	Market	Restaurant / Café / Food Stalls	Tourist Place	Office	School	Hotel	Road Sweeping	Worship Place	Bus Station / Railway Station	Hospital
1	Semolowaru	1	1	0	0	0	1	0	1	1	0	0
2	Klampis Ngasem	1	1	1	0	0	1	1	1	1	0	1
3	Gebang Putih	1	0	0	0	0	1	0	0	1	0	0

Table 5. 8 Category of Solid Waste Sources in LPS Neighborhood Area (Cont`d)

No	LPS	Shops	Market	Restaurant / Café / Food Stalls	Tourist Place	Office	School	Hotel	Road Sweeping	Worship Place	Bus Station / Railway Station	Hospital
East Region												
4	Kendangsari	1	0	1	0	1	1	0	1	1	0	1
5	Kutisari PLN	1	1	1	0	0	1	0	0	1	0	1
6	Tenggilis Mejoyo	1	1	0	0	1	1	1	1	1	0	0
7	Rungkut Alang2	1	1	1	0	0	1	0	1	1	0	1
8	Rungkut Menanggal	1	1	1	0	0	1	0	0	1	0	0
South Region												
No	LPS	Shops	Market	Restaurant / Café / Food Stalls	Tourist Place	Office	School	Hotel	Road Sweeping	Worship Place	Bus Station / Railway Station	Hospital
1	Kembang Kuning	1	1	1	0	1	1	1	0	1	0	0
2	Bendul Merisi	1	1	0	0	0	1	0	0	1	0	1
3	Bogangin	1	1	0	0	0	1	1	0	1	0	0
4	Kemlaten	1	0	0	0	0	1	0	0	1	0	0
5	Kebraon	1	1	0	0	0	1	0	0	1	0	0
6	Karangpilang Marinir	1	1	0	0	1	1	0	0	1	0	0
7	Babatan Indah	1	0	1	0	0	1	0	0	1	0	1
8	Pagesangan	1	1	0	1	1	1	0	0	1	0	0

Table 5. 9 Category of Solid Waste Sources in LPS Neighborhood Area (Cont`d)

Central Region												
No	LPS	Shops	Market	Restaurant / Café / Food Stalls	Tourist Place	Office	School	Hotel	Road Sweeping	Worship Place	Bus Station / Railway Station	Hospital
1	Penghela	1	1	0	0	0	1	0	1	1	1	0
2	Simolawang	1	1	0	1	0	1	1	1	1	0	1
3	Tambakrejo	1	1	1	1	1	1	1	1	1	0	1
4	Dinoyo	1	0	1	0	1	1	1	1	1	0	1
5	Kedondong	1	1	1	0	1	1	1	0	1	0	1

The three databases are combined into one database and provided as the matrix database of LPS characteristics. The matrix table is attached in the attachment section.

5.2.2 LPS Cluster based on the Characteristics Assessment

After completing the database, the next step is to conduct the assessment in every LPS based on the weight score of solid waste generation criteria and the LPS characteristic database. This assessment is done to define the characteristic score of LPS in generating solid waste. The calculation example is showed as following for assessment in LPS Wonokusumo Kidul according to equation 5.1:

LPS Wonokusumo Kidul Characteristics Score = (0x0.105x0.649) + (1x0.258x0.649) + (0x0.637x0.649) + (0x0.105x0.177) + (1x0.637x0.177) + (1x0.258x0.177) + (0x0.648x0.067) + (1x0.230x0.067) + (0x0.122x0.067) + (1x0.084x0.107) + (1x0.235x0.107) + (0x0.156x0.107) + (0x0.144x0.107) + (0.042x0.0.107) + (1x0.037x0.107) + (0x0.116x0.107) + (0x0.023x0.107) + (1x0.019x0.107) + (0x0.092x0.107) + (1x0.053x0.107) = 0.387063

The recapitulation of LPS characteristics assessment score is shown in table 5.5 and it is presented in the order from smallest to largest score.

Table 5. 10 Assessment Score of LPS Characteristics

No	LPS	Score
1	Kemlaten	0.137
2	Karangpilang Marinir	0.241
3	Babatan Indah	0.245
4	Bogangin	0.249
5	Indrapura	0.250
6	Dupak Bangunsari	0.257
7	Kebraon	0.261
8	Kutisari PLN	0.277
9	Babaan	0.304
10	Gebang Putih	0.310
11	Klampis Ngasem	0.320
12	Semolowaru	0.331
13	Rungkut Menanggal	0.345
14	Dinoyo	0.352
15	Pagesangan	0.374
16	Krembangan Barat	0.376

Table 5. 11 Assessment Score of LPS Characteristics (Cont`d)

No	LPS	Score
17	Wonokusumo Kidul	0.387
18	Bendul Merisi	0.387
19	Kedondong	0.393
20	Penghela	0.394
21	Tenggilis Mejoyo	0.402
22	Rungkut Alang2	0.407
23	Ampel	0.420
24	Simolawang	0.445
25	Kendangsari	0.597
26	Benteng	0.664
27	Kembang Kuning	0.679
28	Tambakrejo	0.731

From the list of LPS characteristic score provided in table 5.5, it is known that the score is ranged from 0.137 to 0.731. Then this range is divided into smaller range so that within one group the range distance is only 0.05. It is presumed that the LPS within one group are having similar characteristics. Therefore the range distance is reduced to minimize the deviation of solid waste generation within one group. The result shows that there are 8 groups or 8 clusters which shown in table 5.6 until table 5.13.

The sampling location is selected per cluster by selecting the highest characteristic score within one cluster to obtain the maximum result of solid waste generation. The selection is determined together with the expert from DKP. The selected sampling location is highlighted in red color shown in each table of cluster.

Table 5. 12 LPS Characteristics – Cluster 1

No	LPS	Estimated Volume	Score
1	Kemlaten	18	0.136965

Table 5. 13 LPS Characteristics – Cluster 2

No	LPS	Estimated Volume	Score
2	Karangpilang Marinir	11	0.240923
3	Babatan Indah	13	0.244996
4	Bogangin	13	0.248841
5	Indrapura	15	0.250453

Table 5. 14 LPS Characteristics – Cluster 3

No	LPS	Estimated Volume	Score
6	Dupak Bangunsari	23	0.256973
7	Kebraon	23	0.261407
8	Kutisari PLN	25	0.277377

Table 5. 15 LPS Characteristics – Cluster 4

No	LPS	Estimated Volume	Score
9	Babaan	31	0.304458
10	Gebang Putih	31	0.310581
11	Klampis Ngasem	32	0.320256
12	Semolowaru	30	0.330951
13	Rungkut Menanggal	33	0.345182
14	Dinoyo	35	0.352311

Table 5. 16 LPS Characteristics – Cluster 5

No	LPS	Estimated Volume	Score
15	Pagesangan	39	0.374213
16	Krembangan Barat	38	0.376172
17	Bendul Merisi	40	0.387063
18	Wonokusumo Kidul	40	0.387063
19	Kedondong	38	0.39358
20	Penghela	37	0.393697

Table 5. 17 LPS Characteristics – Cluster 6

No	LPS	Estimated Volume	Score
21	Tenggilis Mejoyo	43	0.401684
22	Rungkut Alang Alang	40	0.407071
23	Ampel	45	0.420549
25	Simolawang	46	0.44535

Table 5. 18 LPS Characteristics – Cluster 7

No	LPS	Estimated Volume	Score
24	Kendangsari	52	0.597219

Table 5. 19 LPS Characteristics – Cluster 8

No	LPS	Estimated Volume	Score
26	Benteng	80	0.664599
27	Kembang Kuning	89	0.679546
28	Tambakrejo	110	0.731092

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CHAPTER VI

SAMPLING OF SOLID WASTE VOLUME MEASUREMENT AND EXPERIMENT OF SOLID WASTE LOSS FACTOR

This chapter consists of the explanation on the model used to determine the conversion factor to estimate the weight of solid waste collected in LPS. Comprehensive explanations from the sampling of solid waste volume measurement and the experiment of solid waste loss factor in order to figure out the most appropriate density factor are also presented in this chapter.

6.1 Model of Solid Waste Conversion Factor

One of the objectives in this research is to find the most appropriate method to estimate the weight of solid waste in LPS. A model of estimation is prepared according to the real condition found in the field so that the model could well represent the real system. Figure 6.1 represents the system of solid waste transportation from LPS to TPA which becomes the scope of this research. The figure enables to identify the critical parameters required to build an appropriate estimation model.

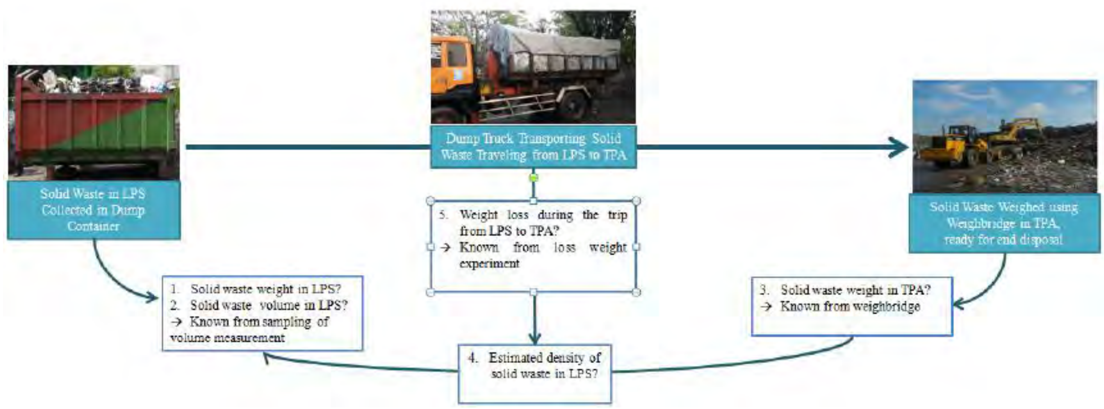


Figure 6. 1 System of Solid Waste Transportation from LPS to TPA

According to the system represented in figure 6.1, the model that can be used to estimate the density of solid waste in LPS can be defined as following equation:

SW Density in LPS = $\frac{SW\ Weight\ in\ LPS}{SW\ Volume\ in\ LPS}$

SW Density in LPS = $\frac{SW\ Weight\ in\ TPA + Weight\ Loss\ during\ Trip}{SW\ Volume\ in\ LPS}$ ….. (6.1)

It is presumed that the factor to convert volume into weight unit or vice versa is using density. The general equation to define density is normally known as the amount of weight per unit volume. Thus there are two important parameters used to determine the density of solid waste in LPS, that is the weight and volume of solid waste in LPS. In the existing system, the volume of solid waste is obtained by dividing the weight of solid waste in TPA with density factor. However from the analysis in chapter 4, it is known that the density factor used to convert weight into volume is not accurate and improperly used inconsistently. Therefore to obtain more accurate data of solid waste volume in LPS, sampling to measure the accurate volume is necessary to be done.

Another parameter that is the weight of solid waste in LPS is still unknown. Even though the weight of solid waste in TPA is known from the weighbridge, but it is presumed that the weight in LPS is actually higher than the weight in TPA. To obtain the more accurate weight in LPS, another factor is needed to be added, that is weight loss occurred during trip. Thus an experiment to figure out the weight loss is required to be done to complete the missing parameter to build up the model.

The following section will be discussing furthermore about the method used to define each required parameter to build up the model of solid waste conversion.

6.2 Sampling of Solid Waste Volume Measurement

According to SNI, there are several methods that can be used to figure out the amount of solid waste generation in municipality. Because the purpose of this research is to find the conversion factor of solid waste unit, thus the sampling method used can refer to SNI 19-3964-1995 and SNI M 36-1991-03 regarding with the measurement of the solid waste amount produced by a number of sample (residential or non residential) and conducted for 8 days in a row to enable the analysis of trend data within a week. This sampling is aimed to accurately measure the volume of solid waste being transported from LPS. By having the more accurate solid waste volume, then the result of the conversion factor will be more accurate to estimate the weight of solid waste in LPS.

6.2.1 SOP Sampling of Solid Waste Volume Measurement

Sampling of solid waste volume measurement is conducted 8 days in a row in order to be able to analyze the trend of solid waste generation within a week. The solid waste transportation from one LPS to TPA may be done more than one trip thus it is also required to conduct sampling for all the trips made from each sampling LPS. This is done in order to be able to analyze the trend of solid waste generation within a day.

Due to limitation of sources from DKP management team to conduct this sampling, a team consists of 11 surveyors are prepared to help and assist the process. Before the execution day, a briefing was conducted to inform them their job description, the standard operational procedure they must follow and the equipments required for them to prepare during sampling. Table 6.1 shows the list of required equipments and table 6.2 explains the sampling SOP.

Table 6. 1 Required Equipments of Solid Waste Volume Measurement Sampling

No	Required Equipments
1	Measurement Form
2	Roll Tape
3	Stationary (pen)
4	Gloves
5	Face Mask
6	Camera for Documentation
7	Communication Device

Table 6. 2 SOP Sampling of Solid Waste Measurement

No	SOP Sampling of Solid Waste Measurement
1	Surveyor prepares all the required equipments before going to LPS.
2	Surveyor arrives in LPS according to the normal departure time of dump truck which known by coordinating with the driver of dump truck.

Table 6. 3 SOP Sampling of Solid Waste Measurement (Cont`d)

No	SOP Sampling of Solid Waste Measurement
3	Surveyor measures the dimension of available dump container in LPS and writes it down in the measurement form.
4	When the driver of dump truck is going to depart to TPA, surveyor checks the pile of solid waste inside dump container.
5	If the pile of solid waste is exceeding the fix space of dump container, surveyor measures the dimension of the pile and writes it down in the measurement form.
6	If the solid waste is not exceeding the fix space of dump container, surveyor measures the dimension of empty spaces and writes it down in the measurement form.
7	Before the driver departs to TPA, surveyor writes down the plate number of dump truck, the driver name, and time of departure in the measurement form.
8	Surveyor is responsible to do documentation during sampling process.
9	Surveyor informs to sampling coordinator regarding the departure of dump truck from his/her assigned LPS to TPA

Before sampling was conducted, it is important to do socialization in the sampling LPS so that the workers in LPS are not feeling disturbed and feeling easy to help. During socialization, it is important to gather the information related to the normal departure time of dump truck transporting the solid waste from LPS to TPA. Table 6.3 shows the information of normal departure time of each sampling LPS.

Table 6. 4 Solid Waste Transportation Schedule from LPS to TPA

No	LPS	Ritase	Transporting Schedule
1	Kembang Kuning	4 – 5 rit	1. 05.00 – 06.00 2. 07.00 – 08.00 3. 10.00 – 11.00 4. 13.00 – 15.00
2	Kendangsari	3 rit	1. 04.30 2. 04.30 3. 04.30
3	Simolawang	3 – 4 rit	1. 04.30 – 05.00 2. 07.00 – 07.30 3. 11.00 – 12.30

Table 6. 5 Solid Waste Transportation Schedule from LPS to TPA (Cont`d)

No	LPS	Ritase	Transporting Schedule
4	Penghela	2 rit	1. 06.00 – 06.30 2. 08.30 – 10.00
5	Dinoyo	2 rit	1. 07.00 – 08.00 2. 10.00 – 11.30
6	Kutisari PLN	1 – 2 rit	1. 04.00 – 04.30 2. *Uncertain
7	Indrapura	1 rit	1. 12.00 – 13.30
8	Kemlaten	2 days - 1 rit	* Uncertain

The measurement form used to record all the required information is shown in figure 6.2 and 6.3. The form is divided into two section which consists of measurement section of container dimension and measurement section of additional solid waste pile.

FORM PENGUKURAN VOLUME SAMPAH TERANGKUT
DINAS KEBERSIHAN DAN PERTAMANAN KOTA SURABAYA
PEMERINTAH KOTA SURABAYA
Jl. Menur No. 31 A, Surabaya Jawa Timur, Indonesia (60285) Telp. (031) 5967387, Fax (031) 5967390

Waktu Amatan
Nama LPS
Nama Surveyor

FORM I

Hari, Tanggal	Pengangkutan Ke-	Waktu Pengangkutan	No Plat Kendaraan	Nama Supir	Dimensi Container								
					Dimensi Balok Container			Volume Balok Container (m3)	Dimensi Trapesium Container			Volume Trapesium Container (m3)	Total Volume Container (m3)
					Panjang (cm)	Lebar (cm)	Tinggi (cm)		Alas Atas (cm)	Alas Bawah (cm)	Tinggi (cm)		

Figure 6. 2 Form – Measurement Section of Container Dimension

FORM PENGUKURAN VOLUME SAMPAH TERANGKUT
DINAS KEBERSIHAN DAN PERTAMANAN KOTA SURABAYA
PEMERINTAH KOTA SURABAYA
Jl. Menur No. 31 A, Surabaya Jawa Timur, Indonesia (60285) Telp. (031) 5967387, Fax (031) 5967390

FORM II

Hari, Tanggal	Pengangkutan Ke-	Waktu Pengangkutan	No Plat Kendaraan	Nama Supir	Dimensi Penambahan Timbulan Sampah				Total Volume	Jenis Sampah Tambahan (Beri tanda (x))			
					Tinggi Penambahan	Volume Trapesium Depan (m3)	Volume Prisma Segitiga Belakang (m3)	Total Volume Penambahan Timbulan Sampah (m3)		Perantingan Pohon	Kasur	Sampah Pasar	Sampah lain yang bervolume besar

Figure 6. 3 Measurement Section of Additional Solid Waste Pile

6.2.2 Data Collection of Solid Waste Volume in LPS Sampling Location

The dimension of solid waste generated inside dump container is presented as figure 6.4. Generally most containers are built up as the assembly of upper and lower trapezoid with block as the main compartment. However there are also some containers which built up only with block as the main compartment. The pile of solid waste generation is generally shaped as presented in the figure.

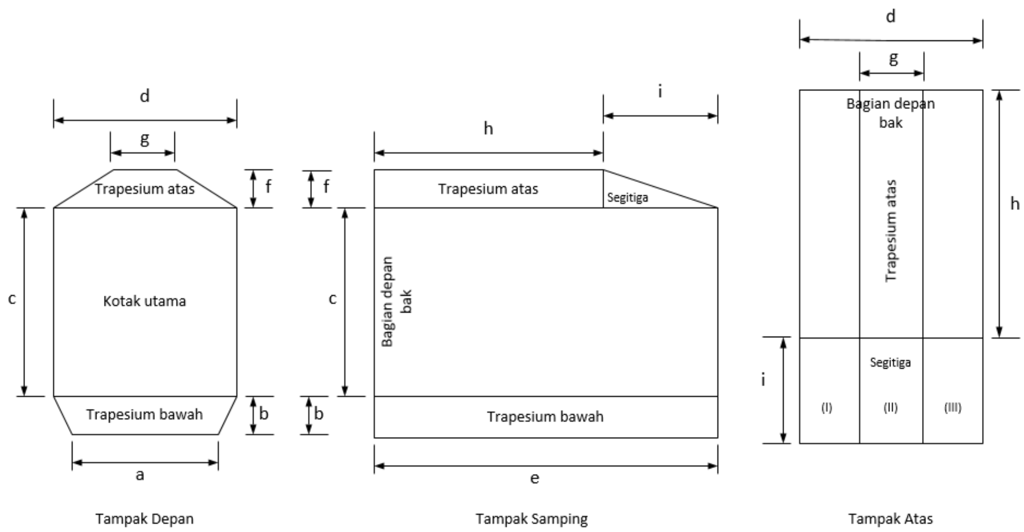


Figure 6. 4 Dimension of Container and Solid Waste Additional Pile

The recapitulation of solid waste volume measurement in each sampling LPS is presented in table 6.4 until table 6.11 Data of solid waste weight measured in TPA using weighbridge is also presented along in the table.

Table 6. 6 Sampling of Solid Waste Volume in LPS Kendangsari

LPS Kendangsari											
Date	Departure Time from LPS		Arrival Time in TPA	Plate Number	Driver Name	Container Dimension			Additional Dimension	Total Solid Waste Volume in LPS (m3)	Total Solid Waste Weight in TPA (kg)
						Block Volume (m3)	Trapezoid Volume (m3)	Total Volume Container (m3)	Total Volume of Additional Waste Pile (m3)		
Tue, 17 Mei	2	4.40	5.54	L 9590 UF	Pak Satuji	13.125	1.932	15.057	4.839	19.896	6310
	3	4.49	6.04	L 9120 UE	-	12.6	1.848	14.448	4.023	18.471	6230
Wed, 18 Mei	3	4.56	6.14	L 9188 UE	Pak Hadi	12.6	1.932	14.532	5.844	20.376	6710
Thur, 19 Mei	3	4.55	6.11	L 9188 UE	Pak Hadi	11.55	1.932	13.482	4.541	18.023	6210
Fri, 20 Mei	3	4.39	5.48	L 9590 UF	Pak Satuji	12.6	1.932	14.532	3.822	18.354	5620
Sat, 21 Mei	1	4.35	6.20		Pak Didik	12.096	1.848	13.944	2.613	16.557	5520
Sun, 22 Mei	1	4.35	5.54	L 8203 FB	Pak Didik	12.6	1.932	14.532	5.076	19.608	5980
	2	4.40	5.55	L 8323 UD	-	13.3056	1.848	15.1536	4.761	19.9146	6530
	3	4.43	5.56	L 8588 UD	-	12.39	1.932	14.322	4.063	18.385	5780
Mon, 23 Mei	1	4.37	5.59	L 8203 FB	Pak Didik	13.104	1.848	14.952	3.248	18.2	5730
	2	4.45	6.00	L 9118 UE	Pak Hadi	12.096	1.848	13.944	3.609	17.553	5520
	3	4.55	6.12	L 9590 UF	Pak Satuji	12.6	1.848	14.448	2.864	17.312	5080
Tue 24 Mei	2	4.46	6.07	L 9590 UF	Pak Satuji	12.6	1.848	14.448	4.8	19.248	6490
	3	4.55	6.08	L 9118 UE	Pak Hadi	13.65	1.932	15.582	4.071	19.653	6870

Table 6. 7 Sampling of Solid Waste Volume in LPS Kutisari PLN

LPS Kutisari PLN											
Date	Departure Time from LPS		Arrival Time in TPA	Plate Number	Driver Name	Container Dimension			Additional Dimension	Total Solid Waste Volume in LPS (m3)	Total Solid Waste Weight in TPA (kg)
						Block Volume (m3)	Trapezoid Volume (m3)	Total Volume Container (m3)	Total Volume of Additional Waste Pile (m3)		
Tue, 17 May	2	6.15	8.12	L 9994 UT	Pak Faisol	12.096	1.848	13.944	1.307	15.251	6260
Wed, 18 May	1	4.20	5.22	L 9994 UT	Pak Faisol	11.088	1.848	12.936	2.07	15.006	5460
	2	6.45	10.16	L 8113 UQ	Pak Kholik	10.584	1.848	12.432	2.1175	14.550	5070
Thur, 19 May	2	12.50	14.56	L 8113 UQ	Pak Kholik	16.128	0	16.128	-1.008	15.12	5270
Fri, 20 May	1	4.50	5.59	L 8113 UQ	Pak Kholik	11.088	1.848	12.936	1.224	14.16	2460
Sat, 21 May	1	8.05	10.11	L 8113 UQ	Pak Kholik	16.128	0	16.128	-1.008	15.12	5090
Sun, 22 May	1	5.25	7.07	L 8113 UQ	Pak Kholik	16.128	0	16.128	-1.512	14.616	5530
Mon, 23 May	1	4.20	5.20	L 8113 UQ	Pak Kholik	12.096	1.848	13.944	1.307	15.251	6420
Tue, 24 May	2	11.3	18.52	L 8113 UQ	Pak Kholik	11.088	1.848	12.936	1.6985	14.635	5230

Table 6. 8 Sampling of Solid Waste Volume in LPS Dinoyo

LPS Dinoyo											
Date	Departure Time from LPS		Arrival Time in TPA	Plate Number	Driver Name	Container Dimension			Additional Dimension	Total Solid Waste Volume in LPS (m3)	Total Solid Waste Weight in TPA (kg)
						Block Volume (m3)	Trapezoid Volume (m3)	Total Volume Container (m3)	Total Volume of Additional Waste Pile (m3)		
Tue, 17 May	1	7.42	8.45	L 8268 UH	Pak Yono	11.088	1.848	12.936	2.624	15.56	3740
	2	13.53	15.17	L 8268 UH	Pak Yono	11.088	1.848	12.936	0.751	13.687	3270
Wed, 18 May	1	7.20	9.01	L 8268 UH	Pak Yono	11.088	1.848	12.936	2.721	15.657	3060
	2	10.42	12.25	L 8268 UH	Pak Yono	11.55	1.932	13.482	3.192	16.674	4410
Thur, 19 May	1	8.25	9.24	L 8268 UH	Pak Yono	11.088	1.848	12.936	2.111	15.047	3540
	2	13.22	14.34	L 8268 UH	Pak Yono	11.088	1.848	12.936	2.684	15.62	3580
Fri, 20 May	1	7.00	8.33	L 8268 UH	Pak Yono	11.088	1.848	12.936	2.703	15.639	2990
	2	13.49	16.46	L 8268 UH	Pak Yono	11.088	1.848	12.936	3.685	16.621	4520
Sat, 21 May	1	7.35	8.58	L 8268 UH	Pak Yono	9.66	1.764	11.424	0.496	11.92	3060
	2	11.16	12.41	L 8872 UP	Pak Sutrisno	9.66	1.764	11.424	2.543	13.967	3180
Sun, 22 May	1	10.02	10.52	W 8844 UY	Pak Mutaris	10.5	1.932	12.432	2.412	14.844	3970
Mon, 23 May	1	9.20	10.44	W 8844 UY	Pak Mutaris	9.576	1.848	11.424	3.381	14.805	3830
	2	12.15	14.10	L 8872 UP	Pak Sutrisno	9.576	1.848	11.424	7.728	19.152	5250
Tue, 24 May	1	7.20	8.59	L 8872 UP	Pak Sutrisno	9.576	1.848	11.424	3.158	14.582	3960
	2	12.15	18.52	L 8268 UA	Pak Yono	10.5	1.932	12.432	2.424	14.856	4560

Table 6. 9 Sampling of Solid Waste Volume in LPS Indrapura

LPS Indrapura											
Date	Departure Time from LPS		Arrival Time in TPA	Plate Number	Driver Name	Container Dimension			Additional Dimension	Total Solid Waste Volume in LPS (m3)	Total Solid Waste Weight in TPA (kg)
						Block Volume (m3)	Trapezoid Volume (m3)	Total Volume Container (m3)	Total Volume of Additional Waste Pile (m3)		
Tue, 17 May	1	13.10	17.11	BE 9206 AL	Pak Hadi	11.55	1.932	13.482	1.3575	14.8395	3830
Wed, 18 May	1	12.55	16.54	BE 9206 AL	Pak Hadi	13.125	0	13.125	-1.05	12.075	3450
Thur, 19 May	1	12.32	13.46	L 8089 MM	Pak Saipul	13.125	0	13.125	-1.575	11.55	2680
Fri, 20 May	1	14.29	15.22	L 8089 MM	Pak Saipul	11.55	1.932	13.482	1.69	15.172	4950
Sat, 21 May	1	11.55	13.37	L 8089 MM	Pak Saipul	13.02	1.932	14.952	0.984	15.936	4420
Sun, 22 May	1										
Mon, 23 May	1	15.00	17.02	L 8089 MM	Pak Saipul	11.55	1.932	13.482	2.525	16.007	5210
Tue, 24 May	1	15.35	17.44	L 8089 MM	Pak Saipul	10.5	1.932	12.432	-1.575	10.857	4160

Table 6. 10 Sampling of Solid Waste Volume in LPS Penghela

LPS Penghela											
Date	Departure Time from LPS		Arrival Time in TPA	Plate Number	Driver Name	Container Dimension			Additional Dimension	Total Solid Waste Volume in LPS (m3)	Total Solid Waste Weight in TPA (kg)
						Block Volume (m3)	Trapezoid Volume (m3)	Total Volume Container (m3)	Total Volume of Additional Waste Pile (m3)		
Tue, 17 May	1	5.30	6.54	W 8472 UY	Pak Iwan	13.5	2.097	15.597	2.248	17.845	4940
	2	10.00	11.26	W 8472 UY	Pak Iwan	10.2375	2.62125	12.85875	4.795	17.654	4330
Wed, 18 May	1	5.30	6.27	W 8472 UY	Pak Iwan	13.5	2.097	15.597	4.645	20.242	4620
	2	10.30	12.13	W 8472 UY	Pak Iwan	12.4476	2.622	15.0696	5.710	20.779	5000
Thur, 19 May	1	5.30	7.24	W 8472 UY	Pak Iwan	13.5	2.097	15.597	6.294	21.891	5360
	2	8.30	10.38	W 8472 UY	Pak Iwan	10.68	2.43637	13.116375	4.984	18.100	4830
Fri, 20 May	1	5.32	6.20	W 8472 UY	Pak Iwan	14.21784	0	14.21784	5.158	19.375	5220
	2	7.30	9.00	W 8472 UY	Pak Iwan	11.34567	1.40476	12.75043	5.055	17.805	4770
Sat, 21 May	1	5.45	7.32	W 8472 UY	Pak Iwan	12.4476	2.622	15.0696	3.426	18.495	5210
	2	8.10	9.44	W 8472 UY	Pak Iwan	9.3525	2.49937	11.851875	4.605	16.457	4970
Sun, 22 May	1	5.45	6.38	W 8472 UY	Pak Iwan	10.68	2.43637	13.116375	0.356	13.472	3380
	2	8.30	10.36	W 8472 UY	Pak Iwan	12.65	2.645	15.295	3.467	18.762	4860
Mon, 23 May	1	5.30	6.18	W 8472 UY	Pak Iwan	15.8235	0	15.8235	5.179	21.003	5810
	2	8.00	9.41	W 8472 UY	Pak Iwan	11.23542	1.4238	12.65922	4.813	17.472	4310
Tue, 24 May	1	5.30	6.30	W 8472 UY	Pak Iwan	15.75	0	15.75	4.568	20.318	5520
	2	10.10	11.54	W 8472 UY	Pak Iwan	9.3525	2.499375	11.851875	5.117	16.969	5410

Table 6. 11 Sampling of Solid Waste Volume in LPS Kembang Kuning

LPS Kembang Kuning											
Date	Departure Time from LPS		Arrival Time in TPA	Plate Number	Driver Name	Container Dimension			Additional Dimension	Total Solid Waste Volume in LPS (m3)	Total Solid Waste Weight in TPA (kg)
						Block Volume (m3)	Trapezoid Volume (m3)	Total Volume Container (m3)	Total Volume of Additional Waste Pile (m3)		
Tue, 17 May	1	5.30	6.58	BA 8401 B	Pak Haryono	11.25	2.0925	13.3425	5.11875	18.461	7110
	2	9.30	11.59	L 8416 UG	Pak Napik	17.136	0	17.136	3.1311	20.267	7900
	3	11.00	15.58	L 8416 UG	Pak Napik	12.3165	2.4675	14.784	3.4293	18.213	7660
Wed, 18 May	1	6.10	7.37	L 8416 UG	Pak Napik	12.3165	2.4675	14.784	5.964	20.748	8810
	2	6.40	10.18	BA 8401 B	Pak Haryono	17.136	0	17.136	3.5784	20.714	7540
	3	8.45	10.54	L 8416 UG	Pak Napik	10.143	1.2915	11.4345	5.208	16.642	5910
	4	13.00	17.06	BA 8401 B	Pak Haryono	11.25	2.0925	13.3425	6.93	20.272	8110
Thur, 19 May	1	7.00	8.54	BA 8401 B	Pak Haryono	12.1986	1.9602	14.1588	4.581	18.740	7420
	2	7.50	11.00	L 8416 UG	Pak Napik	12.075	2.44125	14.51625	5.439	19.955	7830
	3	10.05	11.41	L 8416 UG	Pak Napik	11.55	1.932	13.482	5.1975	18.679	6530
Fri, 20 May	1	6.39	8.34	BA 8401 B	Pak Haryono	17.136	0	17.136	4.10025	21.236	8580
	2	7.04	9.39	L 8416 UG	Pak Napik	16.0536	0	16.05366	2.6455	18.699	7490
	3	9.50	11.26	L 8416 UG	Pak Napik	10.143	1.2915	11.4345	2.7993	14.234	5680
Sat, 21 May	1	6.10	7.36	BA 8401 B	Pak Haryono	9.87	2.2575	12.1275	3.319	15.446	6800
	2	7.30	8.55	L 8416 UG	Pak Napik	12.3165	2.4675	14.784	4.10025	18.884	7400
	3	10.37	12.06	L 8416 UG	Pak Napik	17.136	0	17.136	2.982	20.116	7680
Sun, 22 May	1	6.00	8.29	BA 8401 B	Pak Haryono	12.3165	2.4675	14.784	3.8766	18.661	7150

Table 6. 12 Sampling of Solid Waste Volume in LPS Kembang Kuning (Cont`d)

LPS Kembang Kuning											
Date	Departure Time from LPS		Arrival Time in TPA	Plate Number	Driver Name	Container Dimension			Additional Dimension	Total Solid Waste Volume in LPS (m3)	Total Solid Waste Weight in TPA (kg)
						Block Volume (m3)	Trapezoid Volume (m3)	Total Volume Container (m3)	Total Volume of Additional Waste Pile (m3)		
	2	7.30	8.34	L 8416 UG	Pak Napik	12.852	0.9975	13.8495	6.4113	20.261	8830
	3	10.02	11.26	L 8416 UG	Pak Napik	12.075	2.44125	14.51625	5.5125	20.029	8240
	4	11.40	13.03	L 8416 UG	Pak Napik	10.143	1.2915	11.4345	5.859	17.293	3980
Mon, 23 May	1	6.30	10.02	L 8416 UG	Pak Napik	10.6042	1.8368	12.44104	6.238	18.679	7630
	2	11.30	13.00	BA 8401 B	Pak Haryono	11.3380	1.49292	12.830961	6.4	19.231	8690
	3	16.00		BA 8401 B	Pak Haryono	11.9848	1.46718	13.452076	7.783	21.235	9400
Tue, 24 May	1	5.45	7.43	BA 8401 B	Pak Haryono	17.136	0	17.136	4.473	21.609	8970
	2	6.20	10.09	L 8416 UG	Pak Napik	12.075	2.44125	14.51625	5.5125	20.029	7150
	3	6.40	10.58	BA 8401 B	Pak Haryono	17.136	0	17.136	3.7275	20.863	7200
	4	12.20	13.11	L 8416 UG	Pak Napik	12.3165	2.4675	14.784	5.59125	20.375	7190

Table 6. 13 Sampling of Solid Waste Volume in LPS Simolawang

LPS Simolawang											
Date	Departure Time from LPS		Arrival Time in TPA	Plate Number	Driver Name	Container Dimension			Additional Dimension	Total Solid Waste Volume in LPS (m3)	Total Solid Waste Weight in TPA (kg)
						Block Volume (m3)	Trapezoid Volume (m3)	Total Volume Container (m3)	Total Volume of Additional Waste Pile (m3)		
Tue, 17 May	2	7.33	9.37	BE 9206 AL	Pak Hadi	11.1375	2.15932	13.296825	1.7453	15.042	4840
	3	8.15	13.05	L 8089 MM	Pak Saipul	11.1375	2.15932	13.296825	1.3743	14.671	4840
Wed, 18 May	1	6.30	8.27	BE 9206 AL	Pak hadi	10.5928	0	10.59288	3.842	14.435	4210
	2	8.35	10.31	L 8089 MM	Pak Saipul	10.332	2.373	12.705	2.797	15.502	5300
Thur, 19 May	2	6.25	7.31	L 8089 MM	Pak Saipul	11.1375	2.15932	13.296825	1.653	14.950	4230
	4	16.00		L 9802 US	Pak Anto	10.0220	1.8984	11.92044	4.331	16.251	4420
Fri, 20 May	2	7.05	8.17	L 8089 MM	Pak Saipul	11.1375	2.15932	13.296825	1.225	14.522	4310
	3	8.45	10.27	W 8844 UY	Pak Mutaris	10.625	2.03936	12.6643625	1.7	14.364	3910
	4	11.53	12.53	L 8089 MM	Pak Saipul	10.0533	1.9295	11.982875	1.748	13.731	3710
Sat, 21 May	2	8.15	10.32	L 8089 MM	Pak Saipul	11.1375	2.15932	13.296825	1.703	14.999	4640
	3	9.48	11.26	W 8844 UY	Pak Mukharis	11.1375	2.15932	13.296825	1.672	14.969	4200
Sun, 22 May	2	8.57	10.16	L 8089 MM	Pak Saipul	12.6	1.932	14.532	3.598	18.13	4930
	3	11.43	12.40	L 8089 MM	Pak Saipul	12.0528	1.6605	13.7133	2.012	15.725	3700
Mon, 23 May	2	7.42	9.46	L 8089 MM	Pak Saipul	12.6875	1.8676	14.5551	1.319	15.874	4580
Tue, 24 May	3	12.30	15.16	L 9802 US	Pak Anto	12.6875	1.8676	14.5551	5.021	19.576	5870
	4	17.00		L 9802 US	Pak Anto	10.332	1.8984	12.2304	5.826	18.056	4470

Table 6. 14 Sampling of Solid Waste Volume in LPS Kemlaten

Date	Departure Time from LPS		Arrival Time in TPA	Plate Number	Driver Name	Container Dimension			Additional Dimension	Total Solid Waste Volume in LPS (m3)	Total Solid Waste Weight in TPA (kg)
						Block Volume (m3)	Trapezoid Volume (m3)	Total Volume Container (m3)	Total Volume of Additional Waste Pile (m3)		
Wed, 18 May	1	13.15	14.43	BA 8401 BL	Pak Heri	11.960	-	11.960	3.901	15.861	5,880
Thur, 19 May	1	15.00	16.49	BA 8401 BL	Pak Heri	12.070	1.979	14.049	2.805	16.854	8,310
Sat, 21 May	1	11.38	13.02	BA 8401 BL	Pak Heri	11.960	-	11.960	5.557	17.517	9,050
Mon, 23 May	1	15.16	16.36	BA 8401 BL	Pak Heri	11.960	-	11.960	4.153	16.113	7,900
Tue, 24 May	1	14.15	15.52	BA 8401 BL	Pak Heri	12.070	1.979	14.049	1.646	15.695	5,900

After recapping the data of solid waste volume from LPS sampling location, using software SPSS, data of volume and weight are presented through graph in order to be able to analyze the trend of solid waste generation within a day and within a week. The graph of volume and weight of solid waste are presented in figure 6.5 to 6.12. Further analysis of the graph is explained in following chapter.

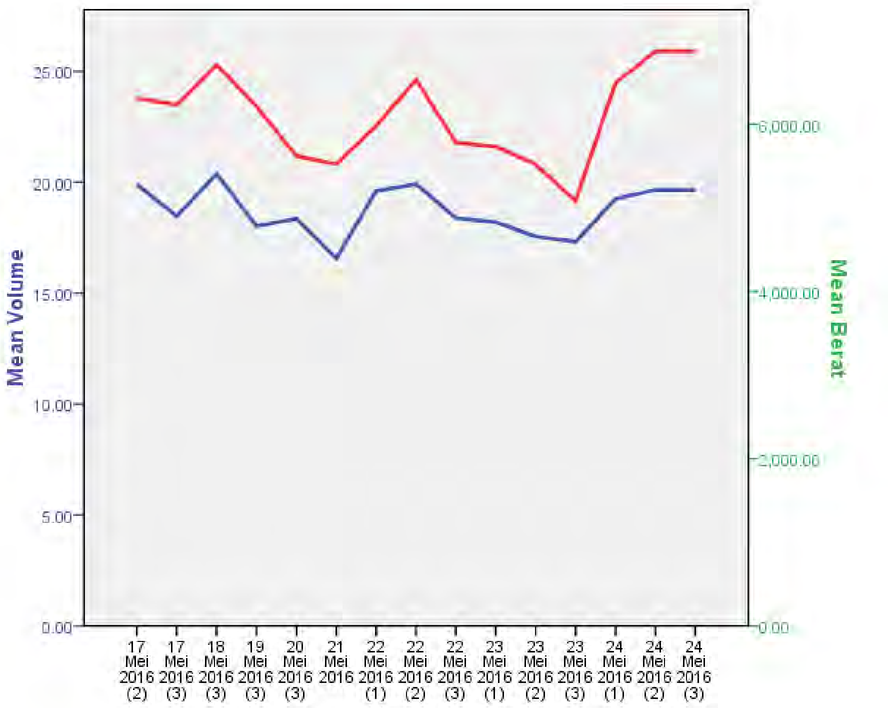


Figure 6. 5 Graph of Volume and Weight of Solid Waste from LPS Kendangsari

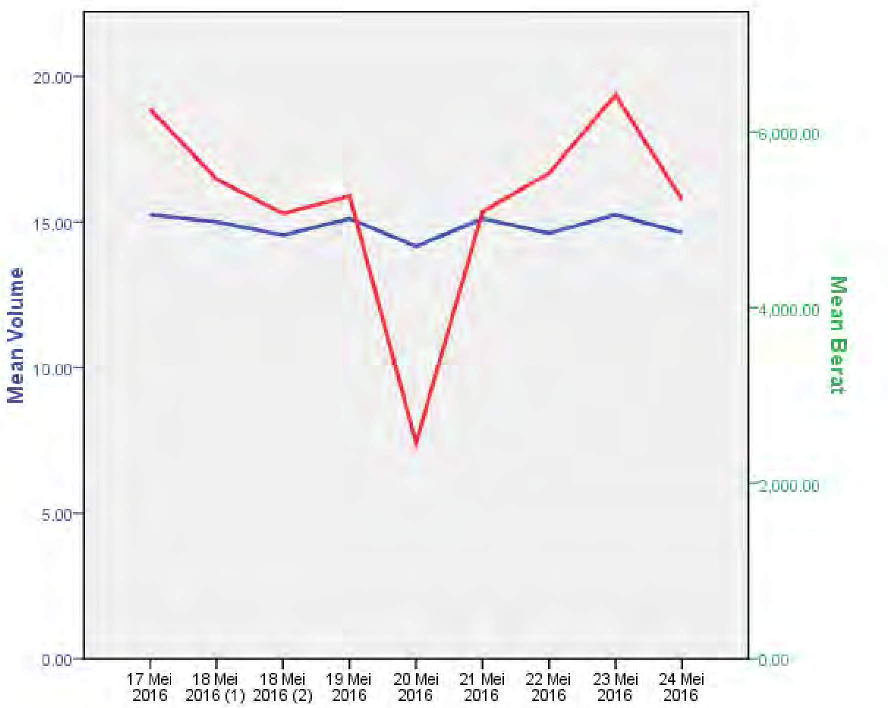


Figure 6. 6 Graph of Volume and Weight of Solid Waste from LPS Kutisari PLN

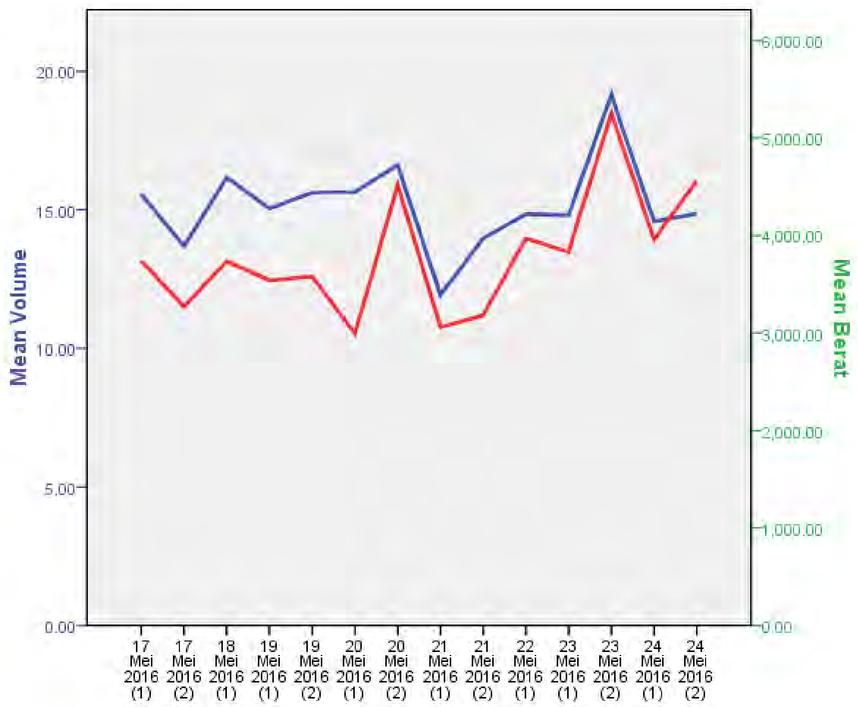


Figure 6. 7 Graph of Volume and Weight of Solid Waste from LPS Dinoyo

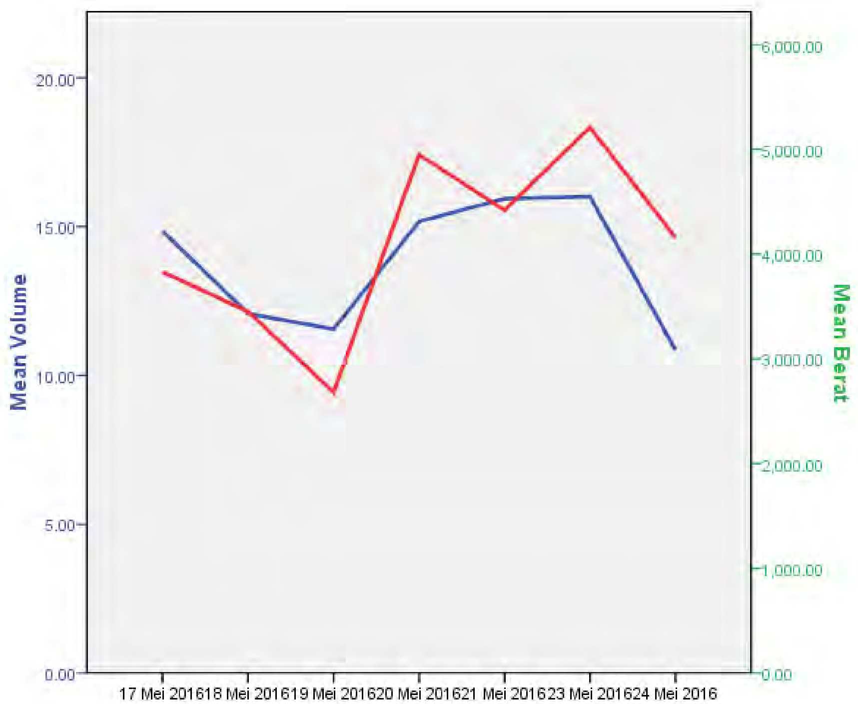


Figure 6. 8 Graph of Volume and Weight of Solid Waste from LPS Indrapura

Figure 6. 9 Graph of Volume and Weight of Solid Waste from LPS Penghela

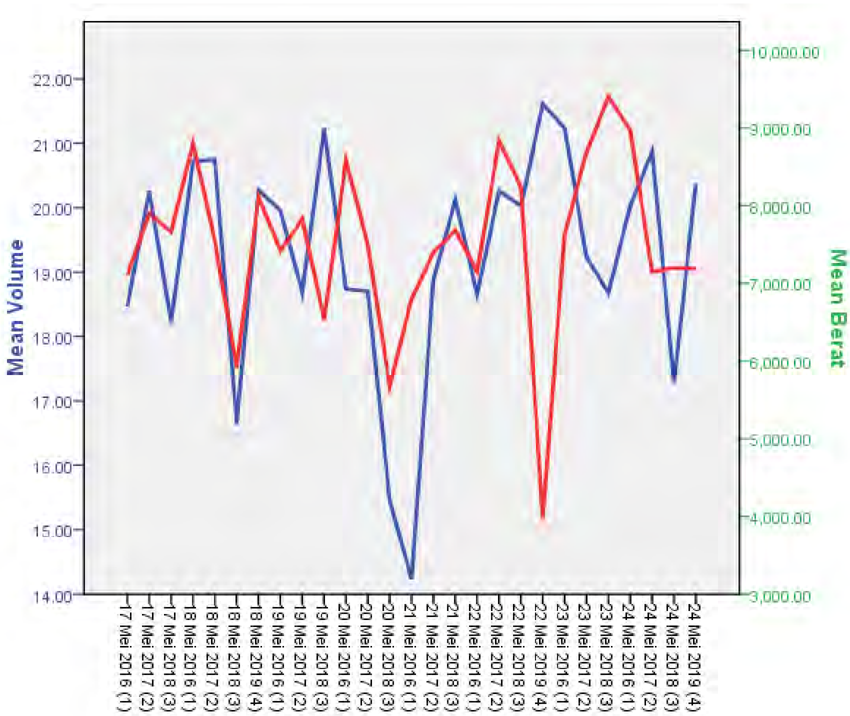


Figure 6. 10 Graph of Volume and Weight of Solid Waste from LPS Kembang Kuning

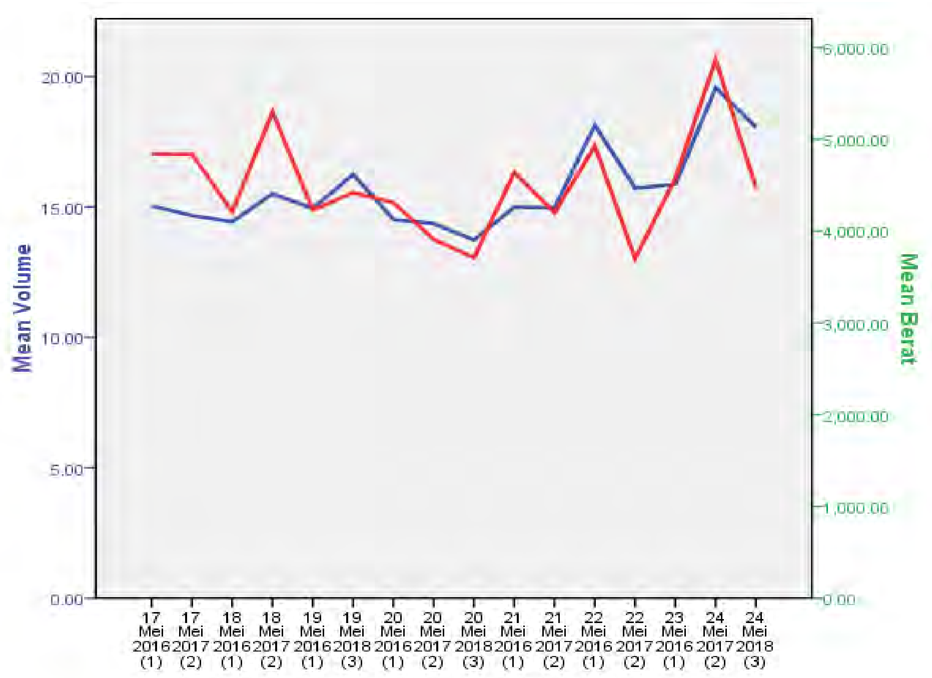


Figure 6. 11 Graph of Volume and Weight of Solid Waste from LPS Simolawang

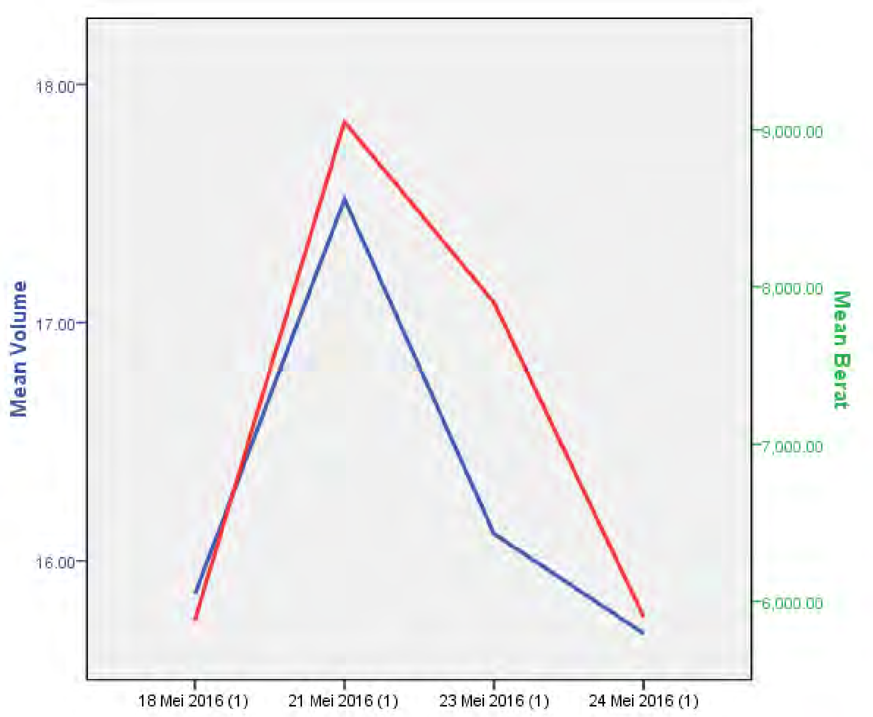


Figure 6. 12 Graph of Volume and Weight of Solid Waste from LPS Kemlaten

6.2.3 Uniformity Test

Data is said to be uniform when it falls in between upper control limit and lower control limit. The example of uniformity test done for data collected in LPS Kendangsari is shown as following:

Average of Solid Waste Volume

$$\bar{x} = \frac{x1+x2+x3+\cdots+x13+x14}{n} \quad \ldots\ldots (6.2)$$

$$\bar{x} = \frac{19.896+18.471+20.376+\cdots+19.248+19.653}{14} = 18.682 \text{ m}^3$$

Standard Deviation

$$\sigma = \sqrt{\frac{\sum(xi-\bar{x})^2}{n-1}} \ldots\ldots (6.3)$$

$$\sigma = \sqrt{\frac{\sum(19.896-18.682)^2+\ldots+(19.63-18.682)^2}{14-1}} = 1.128$$

Standard Deviation and Average Distribution

$$\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}} \ldots\ldots\ldots (6.4)$$

$$\sigma_{\bar{x}} = \frac{1.128}{\sqrt{14}} = 0.302$$

Upper Control Limit (UCL) and Lower Control Limit (LCL) according to equation 6.2 and 6.4 is :

$$\text{UCL} = 18.682 + 3\,(0.302) = 19.587 \text{ m}^3$$

$$\text{LCL} = 18.682 - 3\,(0.302) = 17.777 \text{ m}^3$$

Table 6.12 shows the recapitulation of UCL and LCL to be used for the uniformity test in each LPS sampling location.

Table 6. 15 UCL and LCL of Solid Waste Volume

LPS	UCL (m^3)	LCL (m^3)
Kendangsari	19.587	17.777
Kutisari PLN	15.237	14.476
Dinoyo	16.482	14.002
Indrapura	16.273	11.280
Penghela	20.098	16.982
Kembang Kuning	20.262	18.225
Simolawang	16.878	14.472
Kemlaten	17.430	15.385

6.2.4 Adequacy Test

Adequacy test is done to check whether the amount of data collected has sufficient to be processed in order to continue the analysis of the research. To calculate the minimum number of data needed for accuracy level 5% and confidence level 95% is following the equation:

$$N' = \left[\frac{\frac{C}{\alpha}\sqrt{N\ \sum_{i=1}^{N} x_i^2 - (\sum_{i=1}^{N} x_i)^2}}{\sum_{i=1}^{N} x_i}\right]^2 \quad \text{.........} (6.5)$$

Known:

C = 2

α = 0.05

The example of adequacy test done in LPS Kendangsari is shown as following with initial sample size (N) is 7.

$$N' = \left[\frac{\frac{2}{0.05}\sqrt{7\ (2350.717) - \ (16443.959)^2}}{128.234}\right]^2 = 1.037$$

Table 6.13 shows the recapitulation of adequacy test done in each LPS sampling location.

Table 6. 16 Adequacy Test of Solid Waste Volume Measurement

LPS	N	N’	Round up N’	Adequacy
Kendangsari	7	1.037	2	Adequate
Kutisari PLN	6	0.066	1	Adequate
Dinoyo	9	1.079	2	Adequate
Indrapura	7	5.919	6	Adequate
Penghela	10	2.582	3	Adequate
Kembang Kuning	14	1.455	2	Adequate
Simolawang	10	1.393	2	Adequate
Kemlaten	4	1.099	2	Adequate

6.3 Experiment of Solid Waste Loss Factor

According to the model used to estimate the weight of solid waste in LPS, the next variable that is still unknown is the loss of solid waste weight during the trip from LPS to TPA. The most likely factor that causing the loss of weight during the trip is the drops of leachate from inside container. Thus an experiment is created in order to figure out the amount of leachate dropping during the trip from LPS to TPA that causing the loss of weight.

A model is prepared according to the real condition found in the field so that the model could well represent the real system. To figure out the total weight of leachate dropping during the trip, an experiment is conducted by measuring the weight of dropping leachate for one minute from the dump container before it is being transported. By having the weight of dropping leachate per minute, the total weight during the trip can be calculated by multiplying the rate with the travel duration. However the road condition during the trip from LPS to TPA is likely affecting the rate of dropping leachate. For instance, when the truck is passing damaged road with high speed, the rate is likely to increase. Thus the road factor is included as the parameter to define the weight loss by adding the road index in the model. Because the condition of road travelled from LPS to TPA can be vary along the trips; then the road index is divided into several internodes according the path that the driver normally travels. By having each road index for every internode, the total weight of dropping leachate along the trips can be more accurately estimated. The model to estimate the weight loss during the trip is written as follow:

Total weight loss = dropping leachate rate x $[\sum(1 + r_i \, . \, k)t_i]$ …… (6.6)

Dropping leachate rate = the weight of dropping leachate per minute

r_i = the road index for road internodes i

k = Constanta that affect the increasing rate of dropping leachate during travel from LPS to TPA

t_i = travel duration when passing road internode i

6.3.1 SOP Experiment of Dropping Leachate in LPS

Experiment to measure the amount of dropping leachate in LPS is conducted in the 8 LPS sampling location as a method used to figure out the loss factor during solid waste transportation from LPS to TPA. Differs from sampling of solid waste volume measurement, dropping leachate experiment was not done by a team due to resource limitation in conducting the experiment. However data for every solid waste transported within a day was tried to be gathered in order to find the average of dropping leachate per day. Table 6.14 shows the list of required equipments and table 6.15 explains the experiment SOP.

Table 6. 17 Required Equipments of Dropping Leachate Experiment

No	Required Equipments
1	Experiment Form
2	Scaling Glass
3	Kitchen Scale
4	Stationary (pen)
5	Gloves
6	Face Mask
7	Camera for Documentation

Table 6. 18 SOP Dropping Leachate Experiment

No	SOP Experiment of Dropping Leachate in LPS
1	Prepares all the required equipments before going to LPS.
2	Measure the weight of empty scaling glass using the kitchen scale. Write down the weight of empty scaling glass
3	The experiment is done according to the departure schedule of dump truck from LPS to TPA.
4	When arrive in LPS, check for the spots of dropping leachate in the container (normally located at the back side of the container).
5	When the driver of dump truck is going to depart to TPA, do the experiment by filling up the empty scaling glass with the leachate drops from the container.
6	Wait for two minutes and write down the volume of dropping leachate contained in the scaling glass.
7	Before the driver departs to TPA, writes down the plate number of dump truck, the driver name, and time of departure in the measurement form.
8	Measure the weight of scaling glass containing dropping leachate using the kitchen scale. Write down the amount of weight.
9	Subtract the weight of scaling glass containing dropping leachate with the weight of empty scaling glass to know the weight of dropping leachate.
10	Surveyor is responsible to do documentation during sampling process.

6.3.2 Dropping Leachate Data Collection in LPS Sampling Location

The weight rate of dropping leachate per minute is obtained from weighing the leachate inside glass scale using weight scale and dividing it into two. The total weight of dropping leachate per minute is obtained by multiplying the rate with the number of leaked spots found in one container. Because the leaked spot that causing the drops of leachate is usually more than one. It is assumed that the rates for all leaked spots within one container are the same. The recapitulation of dropping leachate experiment in each sampling LPS is presented in table 6.15.

Table 6. 19 Experiment of Dropping Leachate in LPS Sampling Location

No	LPS	Rit	Vehicle Plate Number	Departure Time From LPS	Arrival Time in TPA	Leachate Volume per minutes (ml)	Leachate Weight per minutes (mg)	Leaked Spot	Total Weight of Dropping Leachate (mg)	Average Weight of Dropping Leachate (mg)
1	Kutisari	1	L 9994 UT	4.30	7.34	52	55	2	110	123
2		1	L 9994 UT	5.05	6.23	15	17	8	136	
3	Kendangsari	1	L 8588 UD	4.25	5.25	225	260	2	520	414
4		2	L 8203 FB	4.40	5.37	135	137	3	411	
5		3	L 9590 UF	4.49	5.44	150	155	2	310	
6	Kembang Kuning	1	L 8416 UG	6.50	8.06	40	40	6	240	583
7		2	BA 8401 BU	8.05	10.53	230	267	3	801	
8		2	L 8416 UG	8.30	9.54	105	118	6	708	
9	Dinoyo	1	W 8844 UY	8.00	9.23	10	12	2	24	30
10		2	L 8286 UH	11.00	15.36	10	12	3	36	
11	Penghela	2	W 8472 UY	8.38	10.14	50	57	1	57	69
12		1	W 8472 UY	5.45	6.22	8	10	8	80	

Table 6. 20 Experiment of Dropping Leachate in LPS Sampling Location (Cont`d)

No	LPS	Rit	Vehicle Plate Number	Departure Time From LPS	Arrival Time in TPA	Leachate Volume per minutes (ml)	Leachate Weight per minutes (mg)	Leaked Spot	Total Weight of Dropping Leachate (mg)	Average Weight of Dropping Leachate (mg)
13	Simolawang	1	BE 9206 AL	6.30	7.59	5	7	1	7	12
14		2	L 8089 MM	9.10	10.26	20	22	1	22	
15		3	L 8089 MM	12.30	14.36	5	7	1	7	
16	Kemlaten	1	BA 8401 BU	7.45	8.50	50	58	2	116	116
17	Indrapura	1	BE 9206 AL	13.50	16.30	7	10	2	20	20

6.3.3 Road Index and Average Travel Velocity

After conducting experiment to figure out the rate of dropping leachate per minute for each LPS, the next is to define the road index for each internodes passed by dump truck during its travel from LPS to TPA. The idea of inputting road index as one of the parameter that affecting the total weight loss during the trip from LPS to TPA is coming from a concern of the possibility that the rate of dropping leachate when it is measured in LPS is not the same with the rate when it is being on the road. It is presume that there must be increasing rate because the data gathered in LPS is actually the rate when the container is in static condition. However the leachate still keeps dropping even when it is already being picked and transported by dump truck. Thus the factor that affects the increasing rate is generated. Then the factors are converted into quantitative value by indexing each category.

The increase of dropping rate is likely caused by the travel speed of trucks. When the driver increases the speed, the rate is likely to increase. When the driver slowing down the speed, the rate is likely stay stable and similar to the rate obtained from experiment in LPS. There are three category used which considered affecting the change of traveling speed of dump trucks, they are the road width, the road damage, and the road density.

1. The road width

The width of road passed by dump trucks affect the velocity of the travelling trucks. The smaller the width, the slower the velocity is. Meanwhile when the dump trucks are passing the road with wider width, the driver is likely to increase the traveling speed. The road width is divided into three sub categories, which are width road for one car, width road for two cars, with road for three or more cars. Score is given for each sub category. The sub category that likely increase the traveling speed is given 1 or 2. While the sub category that is likely causing the rate stable or similar to the rate in LPS is given score 0.

2. The road damage

The physical condition of road passed by dump trucks affect the increasing rate of dropping leachate. The worse the damage of the road, the higher the likeliness of increasing dropping rate is. Because the solid waste inside container will be shook and there is more compaction occurred inside the container. Thus it will penetrate more leachate to drop. The road damage is divided into four sub categories, which are none damage, minor damage, moderate damage and heavy damage. Score is given for each sub category. The sub category that likely increase the rate is given 1, 2 or 3. While the sub category that is likely causing the rate stable or similar to the rate in LPS is given score 0.

3. The road density

The density of vehicles passing the road passed by dump trucks affect the velocity of the travelling trucks. This category is related to the transportation hour done in each trip. For example the trip done before 5 am will likely having low road density compare to the trip done around 7 to 8 am when most people are traveling to work or school. The more dense the road, the slower the velocity is. Meanwhile when the transportation is done during the low road density, it is likely that the speed is increased. The road density is divided into three sub categories, which are low density, medium density and high density. Score is given for each sub category. The sub category that likely increase the traveling speed is given 1 or 2. While the sub category that is likely causing the rate stable or similar to the rate in LPS is given score 0.

The example to calculate the road index is given for the road passed by dump truck transporting solid waste from LPS Kendangsari to TPA. Because the trips done from this LPS is done in the same schedule, which is around 4.30, thus the matrix table used can be categorized in one table. The road index along Kendangsari road to Jemursari road for the trip around 4.30 – 6.00 is as follow:

= {(0 x 0) + (1 x 1) + (0 x 2)} + {(0 x 3) + (1 x 2) + (0 x 1) + (0 x 0)} + {(0 x 0) + (0 x 1) + (1 x 2)} / maximum score

= 4 / 7

= 0.71

Another required parameter is to figure out the travel duration per each internode. This can be defined by dividing the average velocity (km/min) of travelling dump truck with the distance per each internode. The table recapitulation of the average velocity of each dump truck traveling from every

LPS to TPA is provided in table 6.17. The example of calculating the travel duration along Kendangsari road to Jemursari road for the trip is as follow:

Travel duration = Travel distance for each internode / Average travel velocity

Travel duration = 1.7 km / 0.524 km/min = 3.24 min

Table 6. 21 Average Travel Velocity

No	LPS	Rit	Departure Time from LPS	Arrival Time in TPA	Travel Duration (min)	Distance (km)	Average Velocity = distance / travel duration (km/min)	
1	Kutisari	1	4.30	7.34	83.8	31.6	0.377	0.274
2		1	5.05	6.23	78		0.405	
3	Kendangsari	1	4.25	5.25	60	30	0.500	0.524
4		2	4.40	5.37	57		0.526	
5		3	4.49	5.44	55		0.545	
6	Kembang Kuning	1	6.50	8.06	76	23	0.303	0.238
7		2	8.05	10.53	168		0.137	0.205
8		2	8.30	9.54	84		0.274	
9		3			103		0.223	0.223
10	Dinoyo	1	8.00	9.23	83	25.4	0.306	0.306
11		2	11.00	15.36	92		0.276	0.276
12	Penghela	2	8.38	10.14	96	20	0.208	0.208
13		1	5.45	6.22	37		0.541	0.541
15	Simolawang	1	6.30	7.59	89	26	0.292	0.292
16		2	9.10	10.26	76		0.342	0.342
17		3			96		0.271	0.271
18	Kemlaten	1	7.45	8.50	65	28	0.431	0.431
19	Indrapura	1			96	24	0.250	0.250

Table 6. 22 The Road Index from LPS Kendangsari to TPA for all ritase

LPS	Kendangsari													
Route	Kendangsari - Raya Jemursari - Ahmad Yani - Diponegoro - Banyu Urip - Tol Margorejo - keluar langsung ke TPA													
Distance	30 km													
Rit / Transportation Schedule	1,2,3 (04.30 - 06.00)													
Road Internode	Km	Average Velocity (km/min)	Travel Duration	Road Width			Road Damage				Road Density			Road Index
				1 car	2 cars	3 or more cars	Heavy	Moderate	Minor	None	High	Medium	Low	
				0	1	2	3	2	1	0	0	1	2	
Kendangsari - Jemur Andayani	1.7	0.524	3.24		1			1					1	0.71
Ahmad Yani - KBS	4.2	0.524	8.02			1				1			1	0.57
KBS - Perempatan Diponegoro Kupang	2.5	0.524	4.77			1				1			1	0.57
Raya Banyu Urip - Pasar Simo	2.3	0.524	4.39		1				1				1	0.57
Pasar Simo - Raya Tandes	3.3	0.524	6.30			1			1				1	0.71
Jalan masuk ke Tol Margorejo	2	0.524	3.82			1			1				1	0.71
Tol Margorejo	7.5	0.524	14.32			1			1				1	0.71
Romokalisari - TPA	6.5	0.524	12.41		1			1					1	0.71

Table 6. 23 The Road Index from LPS Kutisari PLN to TPA for ritase 1

LPS	Kutisari													
Route	Kutisari PLN - Raya Jemursari - Ahmad Yani - Diponegoro - Banyu Urip - Tol Margorejo - keluar langsung ke TPA													
Distance	31.9 km													
Rit / Transportation Schedule	1 (04.30 - 06.00)													
Road Internode	Km	Average Velocity (km/min)	Travel Duration	Road Width			Road Damage				Road Density			Road Index
				1 car	2 cars	3 or more cars	Heavy	Moderate	Minor	None	High	Medium	Low	
				0	1	2	3	2	1	0	0	1	2	
Kutisari PLN - Keluar gerbang Kutisari	1.5	0.274	5.47	1					1				1	0.43
Kendangsari - Jemur Andayani	2.1	0.274	7.65		1			1					1	0.71
Ahmad Yani - KBS	4.2	0.274	15.31			1				1			1	0.57
KBS - Perempatan Diponegoro Kupang	2.5	0.274	9.11			1				1			1	0.57
Raya Banyu Urip - Pasar Simo	2.3	0.274	8.38		1				1				1	0.57
Pasar Simo - Raya Tandes	3.3	0.274	12.03			1			1				1	0.71
Jalan masuk ke Tol Margorejo	2	0.274	7.29			1			1				1	0.71
Tol Margorejo	7.5	0.274	27.33			1			1				1	0.71
Romokalisari - TPA	6.5	0.274	23.69		1			1					1	0.71

Table 6. 24 The Road Index from LPS Kutisari PLN to TPA for ritase 2

LPS	Kutisari													
Route	Kutisari PLN - Raya Jemursari - Ahmad Yani - Diponegoro - Banyu Urip - Tol Margorejo - keluar langsung ke TPA													
Distance	31.9 km													
Rit / Transportation Schedule	2 (10.00 - 12.00)													
Road Internode	Km	Average Velocity (km/min)	Travel Duration	Road Width			Road Damage				Road Density			Road Index
				1 car	2 cars	3 or more cars	Heavy	Moderate	Minor	None	High	Medium	Low	
				0	1	2	3	2	1	0	0	1	2	
Kutisari PLN - Keluar gerbang Kutisari	1.5	0.274	5.47	1					1				1	0.43
Kendangsari - Jemur Andayani	2.1	0.274	7.66		1			1			1			0.43
Ahmad Yani - KBS	4.2	0.274	15.33			1				1	1			0.29
KBS - Perempatan Diponegoro Kupang	2.5	0.274	9.12			1				1		1		0.43
Raya Banyu Urip - Pasar Simo	2.3	0.274	8.39		1				1			1		0.43
Pasar Simo - Raya Tandes	3.3	0.274	12.04			1			1			1		0.57
Jalan masuk ke Tol Margorejo	2	0.274	7.30			1			1			1		0.57
Tol Margorejo	7.5	0.274	27.37			1			1				1	0.71
Romokalisari - TPA	6.5	0.274	23.72		1			1					1	0.71

Table 6. 25 The Road Index from LPS Dinoyo to TPA for ritase 1

LPS	Dinoyo													
Route	Dinoyo - St. Louis - Kartini - Diponegoro - Banyu Urip - Tol Margorejo - keluar langsung ke TPA													
Distance	25.4 km													
Rit / Transportation Schedule	1 (07.30 - 09.00)													
Road Internode	Km	Average Velocity (km/min)	Travel Duration	Road Width			Road Damage				Road Density			Road Index
				1 car	2 cars	3 or more cars	Heavy	Moderate	Minor	None	High	Medium	Low	
				0	1	2	3	2	1	0	0	1	2	
Jl Dinoyo	0.5	0.306	1.63	1					1				1	0.43
St. Louis - Polisi Istimewa	1	0.306	3.27		1				1				1	0.57
Kartini - Perempatan Diponegoro	1.3	0.306	4.25	1					1				1	0.43
Diponegoro - Raya Banyu Urip	1	0.306	3.27			1				1		1		0.43
Raya Banyu Urip - Pasar Simo	2.3	0.306	7.52		1				1			1		0.43
Pasar Simo - Raya Tandes	3.3	0.306	10.78			1			1			1		0.57
Jalan masuk ke Tol Margorejo	2	0.306	6.54			1			1			1		0.57
Tol Margorejo	7.5	0.306	24.51			1			1				1	0.71
Romokalisari - TPA	6.5	0.306	21.24		1			1				1		0.57

Table 6. 26 The Road Index from LPS Dinoyo to TPA for ritase 2

LPS	**Dinoyo**													
Route	**Dinoyo - St. Louis - Kartini - Diponegoro - Banyu Urip - Tol Margorejo - keluar langsung ke TPA**													
Distance	**25.4 km**													
Rit / Transportation Schedule	**2 (10.00 - 12.30)**													
Road Internode	**Km**	**Average Velocity (km/min)**	**Travel Duration**	**Road Width**			**Road Damage**				**Road Density**			**Road Index**
				1 car	**2 cars**	**3 or more cars**	**Heavy**	**Moderate**	**Minor**	**None**	**High**	**Medium**	**Low**	
				0	**1**	**2**	**3**	**2**	**1**	**0**	**0**	**1**	**2**	
Jl Dinoyo	0.5	0.276	1.81	1					1			1		0.29
St. Louis - Polisi Istimewa	1	0.276	3.62		1				1		1			0.29
Kartini - Perempatan Diponegoro	1.3	0.276	4.71	1					1				1	0.43
Diponegoro - Raya Banyu Urip	1	0.276	3.62			1				1			1	0.57
Raya Banyu Urip - Pasar Simo	2.3	0.276	8.33		1				1				1	0.57
Pasar Simo - Raya Tandes	3.3	0.276	11.95			1			1				1	0.71
Jalan masuk ke Tol Margorejo	2	0.276	7.24			1			1			1		0.57
Tol Margorejo	7.5	0.276	27.17			1			1				1	0.71
Romokalisari - TPA	6.5	0.276	23.54		1			1				1		0.57

Table 6. 27 The Road Index from LPS Kembang Kuning to TPA for ritase 1

LPS	**Kembang Kuning**													
Route	**Kembang Kuning - Diponegoro - Banyu Urip - Tol Margorejo - keluar langsung ke TPA**													
Distance	**23km**													
Rit / Transportation Schedule	**1 (05.30 - 07.00)**													
Road Internode	**Km**	**Average Velocity (km/min)**	**Travel Duration**	**Road Width**			**Road Damage**				**Road Density**			**Road Index**
				1 car	**2 cars**	**3 or more cars**	**Heavy**	**Moderate**	**Minor**	**None**	**High**	**Medium**	**Low**	
				0	**1**	**2**	**3**	**2**	**1**	**0**	**0**	**1**	**2**	
Diponegoro - Raya Banyu Urip	1.4	0.238	5.89			1				1			1	0.57
Raya Banyu Urip - Pasar Simo	2.3	0.238	9.67		1				1				1	0.57
Pasar Simo - Raya Tandes	3.3	0.238	13.88			1			1				1	0.71
Jalan masuk ke Tol Margorejo	2	0.238	8.41			1			1				1	0.71
Tol Margorejo	7.5	0.238	31.54			1			1				1	0.71
Romokalisari - TPA	6.5	0.238	27.34		1			1					1	0.71

Table 6. 28 The Road Index from LPS Kembang Kuning to TPA for ritase 2

LPS	Kembang Kuning													
Route	Kembang Kuning - Diponegoro - Banyu Urip - Tol Margorejo - keluar langsung ke TPA													
Distance	23km													
Rit / Transportation Schedule	2 (07.30 - 09.30)													
Road Internode	Km	Average Velocity (km/min)	Travel Duration	Road Width			Road Damage				Road Density			Road Index
				1 car	2 cars	3 or more cars	Heavy	Moderate	Minor	None	High	Medium	Low	
				0	1	2	3	2	1	0	0	1	2	
Diponegoro - Raya Banyu Urip	1.4	0.205	6.82			1						1		0.43
Raya Banyu Urip - Pasar Simo	2.3	0.205	11.20		1				1			1		0.43
Pasar Simo - Raya Tandes	3.3	0.205	16.07			1			1			1		0.57
Jalan masuk ke Tol Margorejo	2	0.205	9.74			1			1			1		0.57
Tol Margorejo	7.5	0.205	36.52			1			1				1	0.71
Romokalisari - TPA	6.5	0.205	31.65		1			1				1		0.57

Table 6. 29 The Road Index from LPS Kembang Kuning to TPA for ritase 3

LPS	Kembang Kuning													
Route	Kembang Kuning - Diponegoro - Banyu Urip - Tol Margorejo - keluar langsung ke TPA													
Distance	23km													
Rit / Transportation Schedule	3 (10.00 - 12.00)													
Road Internode	Km	Average Velocity (km/min)	Travel Duration	Road Width			Road Damage				Road Density			Road Index
				1 car	2 cars	3 or more cars	Heavy	Moderate	Minor	None	High	Medium	Low	
				0	1	2	3	2	1	0	0	1	2	
Diponegoro - Raya Banyu Urip	1.4	0.223	6.27			1							1	0.57
Raya Banyu Urip - Pasar Simo	2.3	0.223	10.30		1				1				1	0.57
Pasar Simo - Raya Tandes	3.3	0.223	14.78			1			1				1	0.71
Jalan masuk ke Tol Margorejo	2	0.223	8.96			1			1			1		0.57
Tol Margorejo	7.5	0.223	33.59			1			1				1	0.71
Romokalisari - TPA	6.5	0.223	29.11		1			1				1		0.57

Table 6. 30 The Road Index from LPS Penghela to TPA for ritase 1

LPS	Penghela													
Route	Penghela - PGS - Pasar Loak - Tol Dupak - keluar langsung ke TPA													
Distance	20 km													
Rit / Transportation Schedule	1 (05.30 - 07.00)													
Road Internode	Km	Average Velocity (km/min)	Travel Duration	Road Width			Road Damage				Road Density			Road Index
				1 car	2 cars	3 or more cars	Heavy	Moderate	Minor	None	High	Medium	Low	
				0	1	2	3	2	1	0	0	1	2	
Penghela - Jl Semarang	0.3	0.541	0.56		1				1				1	0.57
Raya Dupak - Pintu tol Dupak	2.2	0.541	4.07			1			1				1	0.71
Tol Dupak	11	0.541	20.35			1			1				1	0.71
Romokalisari - TPA	6.5	0.541	12.03		1			1					1	0.71

Table 6. 31 The Road Index from LPS Penghela to TPA for ritase 2

LPS	Penghela													
Route	Penghela - PGS - Pasar Loak - Tol Dupak - keluar langsung ke TPA													
Distance	20 km													
Rit / Transportation Schedule	2 (08.00 - 10.00)													
Road Internode	Km	Average Velocity (km/min)	Travel Duration	Road Width			Road Damage				Road Density			Road Index
				1 car	2 cars	3 or more cars	Heavy	Moderate	Minor	None	High	Medium	Low	
				0	1	2	3	2	1	0	0	1	2	
Penghela - Jl Semarang	0.3	0.208	1.44		1				1			1		0.43
Raya Dupak - Pintu tol Dupak	2.2	0.208	10.56			1			1			1		0.57
Tol Dupak	11	0.208	52.80			1			1				1	0.71
Romokalisari - TPA	6.5	0.208	31.20		1			1				1		0.57

Table 6. 32 The Road Index from LPS Indrapura to TPA for ritase 1

LPS	Indrapura													
Route	Indrapura - HOS - Jl Kalimas - Jl Jakarta - Perak Timur - Jl Gresik - Tol Dupak / Jl. Kalianak - keluar langsung TPA													
Distance	24 km													
Rit / Transportation Schedule	1 (12.00 - 15.00)													
Road Internode	Km	Average Velocity (km/min)	Travel Duration	Road Width			Road Damage				Road Density			Road Index
				1 car	2 cars	3 or more cars	Heavy	Moderate	Minor	None	High	Medium	Low	
				0	1	2	3	2	1	0	0	1	2	
Indrapura - HOS	0.5	0.25	2.00	1					1				1	0.43
HOS - Kebalen Timur	1	0.25	4.00	1				1				1		0.43
Jl. Jakarta	0.5	0.25	2.00		1				1		1			0.29
Jl Perak Timur	1.2	0.25	4.80			1			1		1			0.43
Jl Gresik - Pintu tol	3.3	0.25	13.20			1			1			1		0.57
Tol Demak	11	0.25	44.00			1			1				1	0.71
Romokalisari - TPA	6.5	0.25	26.00		1			1				1		0.57

Table 6. 33 The Road Index from LPS Simolawang to TPA for ritase 1

LPS	Simolawang													
Route	Simolawang - Sidotopo - Pegirian - Jl. Jakarta - Perak Timur - Jl Gresik - Tol Dupak / Jl. Kalianak - keluar langsung TPA													
Distance	26 km													
Rit / Transportation Schedule	1 (05.00 - 07.00)													
Road Internode	Km	Average Velocity (km/min)	Travel Duration	Road Width			Road Damage				Road Density			Road Index
				1 car	2 cars	3 or more cars	Heavy	Moderate	Minor	None	High	Medium	Low	
				0	1	2	3	2	1	0	0	1	2	
Simolawang - Sidotopo Lor	1.3	0.292	4.45		1				1				1	0.57
Sidorame	0.7	0.292	2.40		1				1				1	0.57
Sultan Iskandar Muda	0.8	0.292	2.74		1				1				1	0.57
Jl Jakarta	1.2	0.292	4.11		1				1				1	0.57
Jl Perak Timur	1.2	0.292	4.11			1			1				1	0.71
Jl Gresik - Pintu Tol	3.3	0.292	11.30			1			1				1	0.71
Tol Demak	11	0.292	37.65			1			1				1	0.71
Romokalisari - TPA	6.5	0.292	22.25		1			1					1	0.71

Table 6. 34 The Road Index from LPS Simolawang to TPA for ritase 2

LPS	Simolawang
Route	Simolawang - Sidotopo - Pegirian - Jl. Jakarta - Perak Timur - Jl Gresik - Tol Dupak / Jl. Kalianak - keluar langsung TPA
Distance	26 km
Rit / Transportation Schedule	2 (08.00 - 10.00)

Road Internode	Km	Average Velocity (km/min)	Travel Duration	Road Width			Road Damage				Road Density			Road Index
				1 car	2 cars	3 or more cars	Heavy	Moderate	Minor	None	High	Medium	Low	
				0	1	2	3	2	1	0	0	1	2	
Simolawang - Sidotopo Lor	1.3	0.342	3.80		1				1				1	0.57
Sidorame	0.7	0.342	2.05		1				1		1			0.29
Sultan Iskandar Muda	0.8	0.342	2.34		1				1			1		0.43
Jl Jakarta	1.2	0.342	3.51		1				1		1			0.29
Jl Perak Timur	1.2	0.342	3.51			1			1			1		0.57
Jl Gresik - Pintu Tol	3.3	0.342	9.65			1			1			1		0.57
Tol Demak	11	0.342	32.15			1			1				1	0.71
Romokalisari - TPA	6.5	0.342	19.00		1			1				1		0.57

Table 6. 35 The Road Index from LPS Simolawang to TPA for ritase 3

LPS	Simolawang
Route	Simolawang - Sidotopo - Pegirian - Jl. Jakarta - Perak Timur - Jl Gresik - Tol Dupak / Jl. Kalianak - keluar langsung TPA
Distance	26 km
Rit / Transportation Schedule	3 (11.00 - 13.00)

Road Internode	Km	Average Velocity (km/min)	Travel Duration	Road Width			Road Damage				Road Density			Road Index
				1 car	2 cars	3 or more cars	Heavy	Moderate	Minor	None	High	Medium	Low	
				0	1	2	3	2	1	0	0	1	2	
Simolawang - Sidotopo Lor	1.3	0.271	4.80		1				1			1		0.43
Sidorame	0.7	0.271	2.58		1				1		1			0.29
Sultan Iskandar Muda	0.8	0.271	2.95		1				1			1		0.43
Jl Jakarta	1.2	0.271	4.43		1				1		1			0.29
Jl Perak Timur	1.2	0.271	4.43			1			1		1			0.43
Jl Gresik - Pintu Tol	3.3	0.271	12.18			1			1			1		0.57
Tol Demak	11	0.271	40.62			1			1				1	0.71
Romokalisari - TPA	6.5	0.271	24.00		1			1				1		0.57

Table 6. 36 The Road Index from LPS Kemlaten to TPA for ritase 1

LPS	Kemlaten													
Route	Raya Mastrip - Tol Sby Gempol Gresik - keluar langsung TPA													
Distance	28 km													
Rit / Transportation Schedule	1													
Road Internode	Km	Average Velocity (km/min)	Travel Duration	Road Width			Road Damage				Road Density			Road Index
				1 car	2 cars	3 or more cars	Heavy	Moderate	Minor	None	High	Medium	Low	
				0	1	2	3	2	1	0	0	1	2	
Raya Mastrip - Pintu Masuk Tol	6	0.431	13.92		1				1				1	0.57
Tol I	8	0.431	18.56			1			1				1	0.71
Tol Margorejo	7.5	0.431	17.40			1			1				1	0.71
Romokalisari - TPA	6.5	0.431	15.08		1			1				1		0.57

6.3.4 Data Tabulation of Dropping Leachate during The Travel in Toll

After obtaining the rate of dropping leachate in each LPS sampling location, the next is to conduct an experiment to figure another parameter which is *k*. *k* is a constanta that affect the increasing rate of dropping leachate during travel from LPS to TPA. The idea of inputting constanta in the parameter is coming from the assumption that if the road index score is 1, means that the score for all categories increasing the likeliness of the dropping rate, then the rate during the trip from LPS to TPA is twice the rate of dropping leachate in static state in LPS.

To check if the assumption is confirmed with the actual model occurred during the process, another experiment is done to figure out the rate of *k*. The hypothesis is that if above statement is confirmed, then the result of *k* value from the experiment will be or close to 1. The experiment was done by taking samples of dropping leachate during the travel duration in toll. The example to calculate the value of *k* when solid waste was transported from LPS Dinoyo is provided as follow:

$$C = A \times (1 + (r_{toll})\, k) \times B \;\ldots\ldots (6.7)$$

$$30 = 2.5 \times (1 + (4/7)\, k) \times 10$$

$$1.2 = 1 + (4/7)\, k$$

$$k = 0.2 \times 7/4 = 0.35$$

Table 6. 37 Experiment of Dropping Leachate during Transportation through Toll

No	LPS	Rit	Weight of Dropping Leachate in LPS (mg) A	Travel Duration in Toll (minutes) B	Total Weight of Dropping Leachate C	k
1	**Dinoyo**	1	2.5	10	30	**0.35**
2		2	3	10	40	**0.58**
4	**Kembang Kuning**	1	40	13	780	**0.88**
5		2	35	12	590	**0.71**
6		3	37.5	12	770	**1.24**

The result from the experiment from LPS Dinoyo shows the result of average *k* value is 0.47, it means that when dump truck travels in toll, the rate of dropping leachate is increasing by 0.47 mg per min. While the result from the experiment from LPS Kembang Kuning shows the result of average *k* value is 0.91, it means that when dump truck travels in toll, the rate of dropping leachate is increasing by 0.91 mg per min. For the average *k* value obtained from the overall experiment, the value is 0.75.

The way to decide which *k* value is most appropriate to use in the model is by comparing the result of each value when applied to the model. Further explanation on this calculation is provided in the next sub chapter.

6.3.5 Total Loss Factor

Having all the parameters required to determine the total of weight loss during transportation trip from each LPS sampling location to TPA, the next step is to apply each parameter value into the model to estimate the total loss factor. Recalling the equation 6.5 which used to estimate the total weight loss, the example of table matrix used to calculate the total weight loss in LPS Kendangsari is shown in table 6.33

$$\text{Total weight loss} = \text{dropping leachate rate x } [\sum(1 + r_i \, . \, k)t_i] \text{ ...... (6.6)}$$

Table 6. 38 Total Weight Loss during Transportation from LPS Kendangsari to TPA for k = 0.94

Internode	Km	Average Velocity (km/min)	Travel Duration (min)	Road Index	k	Rate of Leachate Drops Weight	Weight Loss (kg)
Kendangsari - Jemur Andayani	1.7	0.524	3.24	0.71	0.94	414	2.24
Ahmad Yani – KBS	4.2	0.524	8.02	0.57	0.94	414	5.10
KBS - Perempatan Diponegoro Kupang	2.5	0.524	4.77	0.57	0.94	414	3.03
Raya Banyu Urip - Pasar Simo	2.3	0.524	4.39	0.57	0.94	414	2.79
Pasar Simo - Raya Tandes	3.3	0.524	6.30	0.71	0.94	414	4.35
Jalan masuk ke Tol Margorejo	2	0.524	3.82	0.71	0.94	414	2.64
Tol Margorejo	7.5	0.524	14.32	0.71	0.94	414	9.90
Romokalisari – TPA	6.5	0.524	12.41	0.71	0.94	414	8.58
	30		57.26		**Total Weight Loss**		**38.64**

The total of weight loss calculated in each LPS is using two kind of different k. Table 6.34 shows the total of weight loss when k value used is the average of k value from the experiment results. While table 6.35 shows the total of weight loss when k value used is the average of k value from the average of each category of dropping rate.

Table 6. 39 Total Weight Loss during Transportation for k value = 0.75

No	LPS	Distance (km)	Rit	Average Velocity (km/min)	Travel Duration (min)	Loss Factor = k	Total Weight Loss (kg)
1	Kendangsari	30	1,2,3	0.524	57.26	0.75	35.61
2	Kutisari PLN	31.9	1	0.274	116.42	0.75	21.38
			2	0.274	116.42	0.75	20.32
3	Dinoyo	25.4	1	0.306	83	0.75	2.67
			2	0.276	92	0.75	3.01
4	Indrapura	24	1	0.25	96	0.75	1.62
5	Penghela	20	1	0.541	37	0.75	3.89
			2	0.208	96	0.75	9.77

Table 6. 40 Total Weight Loss during Transportation for k value = 0.75 (Cont`d)

No	LPS	Distance (km)	Rit	Average Velocity (km/min)	Travel Duration (min)	Loss Factor = k	Total Weight Loss (kg)
6	Kembang Kuning	23	1	0.238	96.73	0.75	85.63
			2	0.205	112	0.75	94.44
			3	0.223	103	0.75	88.81
7	Simolawang	26	1	0.292	89	0.75	1.62
			2	0.342	76	0.75	1.33
			3	0.271	96	0.75	1.66
8	Kemlaten	28	1	0.431	64.97	0.75	11.21

Table 6. 41 Total Weight Loss during Transportation for 1st k value = 0.94, 2nd k value = 0.71, 3rd k value = 0.47

No	LPS	Distance (km)	Rit	Average Velocity (km/min)	Travel Duration (min)	Loss Factor = k	Total Weight Loss (kg)
1	Kendangsari	30	1,2,3	0.524	57.26	0.94	38.64
2	Kutisari PLN	31.9	1	0.274	116.42	0.71	20.96
			2	0.274	116.42	0.71	19.96
3	Dinoyo	25.4	1	0.306	83	0.47	2.37
			2	0.276	92	0.47	2.65
4	Indrapura	24	1	0.25	96	0.47	2.47
5	Penghela	20	1	0.541	37	0.71	3.81
			2	0.208	96	0.71	9.58
6	Kembang Kuning	23	1	0.238	96.73	0.94	93.04
			2	0.205	112	0.94	101.82
			3	0.223	103	0.94	96.09
7	Simolawang	26	1	0.292	89	0.47	1.42
			2	0.342	76	0.47	1.17
			3	0.271	96	0.47	1.47
8	Kemlaten	28	1	0.431	64.97	0.71	10.99

6.4 Estimated Solid Waste Density in LPS

Having the two important parameters to determine the estimated solid waste density in LPS, which are solid waste volume in LPS and total weight loss during transportation, the next step is to calculate the solid waste density. Recalling the equation to calculate the solid waste density in LPS as follow,

$$\text{SW Density in LPS} = \frac{SW\ Weight\ in\ TPA + Weight\ Loss\ during\ Trip}{SW\ Volume\ in\ LPS} \quad \ldots\ldots (6.1)$$

the example of estimated solid waste density in LPS Kendangsari is shown in table 6.36.

Table 6. 42 Estimated Solid Waste Density in LPS Kendangsari for k=0.75

No	Solid Waste Volume in LPS (m^3)	Solid Waste Weight in TPA (kg)	Weight Loss (kg)	Estimated Solid Waste in LPS (kg)	Estimated Solid Waste Density in LPS (kg/m^3)
1	17.312	5080	35.615	5,115.615	295.4953
2	16.557	5520	35.615	5,555.615	335.5448
3	17.553	5520	35.615	5,555.615	316.5051
4	18.354	5620	35.615	5,655.615	308.1407
5	18.2	5730	35.615	5,765.615	316.792
6	18.385	5780	35.615	5,815.615	316.3239
7	19.608	5980	35.615	6,015.615	306.7939
8	18.023	6210	35.615	6,245.615	346.5358
9	18.471	6230	35.615	6,265.615	339.2136
10	19.896	6310	35.615	6,345.615	318.9392
11	19.248	6490	35.615	6,525.615	339.0282
12	19.9146	6530	35.615	6,565.615	329.6885
13	20.376	6710	35.615	6,745.615	331.0569
14	19.653	6870	35.615	6,905.615	351.3771
Estimated Solid Waste Density in LPS Kendangsari					**324.3139**

The estimated solid waste density is taken by simulating parameter mean, median and mode from the obtained data using error measurement. The parameter having least error percentage is chosen as the best fit estimated density. The result of estimated solid waste density from each LPS for each category of k is provided in table 6.37.

Table 6. 43 Estimated Solid Waste Density

No	LPS	Estimated Solid Waste Density (kg/m^3)	
		k = 0.75	k (vary)
1	Kendangsari	318.939	319.091
2	Kutisari PLN	350.110	350.090
3	Dinoyo	248.850	248.830
4	Indrapura	278.450	278.430
5	Penghela	265.850	265.840
6	Kembang Kuning	400.730	395.020
7	Simolawang	283.050	283.040
8	Kemlaten	490.990	490.970

6.4.1 Error Measurement of Solid Waste Density for the Most Appropriate Loss Factor

Estimated SW Weight in TPA = (SW Volume in LPS x Estimated SW Density in LPS) – Estimated Weight Loss during Trip… (6.8)

Table 6. 44 MAPE Score for each category of k value in LPS Kendangsari

Kendangsari											
Volume	Densitas Estimasi	Weight Loss	Berat TPA	Berat Estimasi TPA	MAPE		Densitas Estimasi	Weight Loss	Berat TPA	Berat Estimasi TPA	MAPE
17.312	318.939	35.615	5080	5,485.86	0.08		319.091	38.636	5080	5,485.47	0.08
16.557	318.939	35.615	5520	5,245.06	0.05		319.091	38.636	5520	5,244.55	0.05
17.553	318.939	35.615	5520	5,562.72	0.01		319.091	38.636	5520	5,562.37	0.01
18.354	318.939	35.615	5620	5,818.19	0.04		319.091	38.636	5620	5,817.96	0.04
18.2	318.939	35.615	5730	5,769.08	0.01		319.091	38.636	5730	5,768.82	0.01
18.385	318.939	35.615	5780	5,828.08	0.01		319.091	38.636	5780	5,827.85	0.01
19.608	318.939	35.615	5980	6,218.14	0.04		319.091	38.636	5980	6,218.10	0.04
18.023	318.939	35.615	6210	5,712.62	0.08		319.091	38.636	6210	5,712.34	0.08
18.471	318.939	35.615	6230	5,855.51	0.06		319.091	38.636	6230	5,855.29	0.06
19.896	318.939	35.615	6310	6,310.00	0.00		319.091	38.636	6310	6,310.00	0.00
19.248	318.939	35.615	6490	6,103.32	0.06		319.091	38.636	6490	6,103.23	0.06
19.914	318.939	35.615	6530	6,315.93	0.03		319.091	38.636	6530	6,315.93	0.03
20.376	318.939	35.615	6710	6,463.09	0.04		319.091	38.636	6710	6,463.16	0.04
19.653	318.939	35.615	6870	6,232.49	0.09		319.091	38.636	6870	6,232.46	0.09
					4.213%						4.212%

The recapitulation of the average MAPE score in each LPS sampling location is provided in table 6.39. The smaller MAPE score is highlighted with color orange.

Table 6. 45 MAPE Score for each k value

MAPE Score			
LPS	**Category**	**k=0.75**	**k (vary)**
Kendangsari	High	4.2131%	4.2124%
Kutisari	Medium	16.7788%	16.7790%
Dinoyo	Low	10.23486%	10.23479%
Indrapura	Low	12.4680%	12.4679%
Penghela	Medium	6.69374%	6.69381%
Kembang Kuning	High	8.4575%	8.4507%
Simolawang	Low	7.46519%	7.46517%
Kemlaten	Medium	13.6630%	13.6632%

It is then known that the difference of MAPE score for each k value is only slightly differ. However when the result is compared to the category of each LPS weight loss rate, those LPS in medium category have the least MAPE score when average k=0.75 is used. While the other LPS whose in category high and low having the least MAPE score when the k value for their own category is used. Meanwhile the k-value for medium category itself is 0.71, which close to the k-value 0.75. Thus it can be concluded that actually there is a correlation between category of dropping leachate rate with k-value.

CHAPTER VII
ANALYSIS OF SAMPLING AND EXPERIMENT RESULT AND EVALUATION OF EXPENDITURE FOR SOLID WASTE TRANSPORTATION

This chapter consists of the analysis from the result obtained in sampling of solid waste volume measurement and in experiment of weight loss during transportation from LPS to TPA. Evaluation of expenditure for solid waste transportation is also discussed by comparing the new conversion factor with the previous conversion factor used by DKP.

7.1 Analysis of Solid Waste Generation in LPS

The sampling aimed to measure the more accurate volume of solid waste generation in LPS has been done for 8 days in a row in the 8 selected sampling LPS. Using software SPSS, graphs are made to show the trend of changes from the sampling result. Graphic line of solid waste volume in LPS and solid waste weigh from TPA are put into one figure for each LPS to make it easy to compare the changes.

The graphs tell that for every increasing weight of solid waste in the following day or following rit, the volume is likely to increase as well. When there is a decreasing of weight, the volume is also likely to decrease. The trend shows that there is correlation between the volume and weight unit of solid waste.

According to the amount of solid waste generated per day, the sampling result shows that the highest amount of solid waste generated in LPS is during early of the week, within Tuesday, Wednesday or Thursday. While the lowest amount is generated during weekend, like Saturday and Sunday. For the rest of solid waste generated in Monday or Friday, the amount tends to be in between the highest and the lowest. Based on the interview done with some garbage men and the officer in LPS, the reason is mostly because of work behavior of the garbage men that affects the generation of solid waste in LPS.

The garbage men tend to work eagerly during the early of the week, so that they collect more garbages from the residents' house and neighborhood area. But because the waste transported from LPS on Monday is actually the waste that is being collected partly on Sunday, in which there are some garbage men who are off of work, thus the amount of solid waste on Monday tend to be less than the other early days of the week. The same trend also appears on the amount of solid waste generated on Friday, which is similar to the amount on Monday. Garbage men tend to work only in the morning because after Jumat prayer there are some of them who are prefer to not continuing the collection activity from residents` house and neighborhood area. Thus it reduces the amount of solid waste generation.

While during weekend, like Saturday and Sunday, there are some garbage men who are off of work so that there will be no collection at all in the residents`s house and neighborhood area. There is also some garbage men who prefer to reduce the frequency of their collection activity during weekend so that they have more free time. This leads to the decreasing amount of waste transferred to LPS. The sampling result shows that during transportation on Sunday, it is likely that the amount is fewer than in any other day.

According to analysis of the amount of solid waste transported per cycle *(ritase)*, there is differences also for the LPS that its waste is transported more than 2 cycles, such as in LPS Kembang Kuning and LPS Simolawang. The first and second cycle of transportation activity tends to carry more amount of solid waste compare to the third or forth cycle. This is due to the schedule of garbage men in collecting garbages from the residents` house and neighborhood area. Garbage men tend to work on collecting garbages in the morning starts before the dawn. Thus the container is filled up quickly in the morning which the first and second transportation cycle is normally done. The first cycle is also transporting the waste that is being collected in previous day, normally in the evening of previous day. Therefore the first cycle has more amount of solid waste to transport.

7.2 Analysis of Weight Loss during Transportation from LPS to TPA

The experiment aimed to figure out the weight loss of solid waste during its transportation process from LPS to TPA has been done in the 8 selected sampling LPS. The experiment itself is done in several stages according to the required parameters mentioned in the estimated model to estimate the total weight loss during the transportation activity. The initial experiment done is by measuring the rate of dropping leachate from the container before it is being transported to obtain the weight loss rate per minute. The following step is to create database of road index which consist of road category that affect the speed of vehicle during its travelling from LPS to TPA. Then the next is to conduct another experiment to figure out the constanta that define the increasing rate of weight loss for any score of road index. After gathering all the required data to complete the model parameters, then the total weight loss during transportation activity can be obtained.

The analysis of the weight loss result is done by categorizing the result into three categories. Table 7.1 presents the category of LPS based on its amount of weight loss when the waste being transported to TPA.

Table 7. 1 Analysis of The Amount of Weight Loss

No	LPS	Category	Analysis
1	Indrapura	Low	The level economy of neighbor residents are dominated with low income residents, it is likely that the residents having less excessive food in their daily garbage. The neighbor area also does not have any nearby restaurant/café/hotel that may dispose excessive food and beverages.
2	Dinoyo		The level economy of neighbor residents are dominated with medium income residents, which tend to producing more excessive food in their daily garbage. But due to the short length of garbage being piled from the residents garbage bin until transferred to LPS (normally the garbage men will collect it every day), there is not much of leachate produced until the process of transportation to TPA. The neighbor area also does not have any nearby restaurant/café/hotel that may disposing excessive food and beverages.

Table 7. 2 Analysis of The Amount of Weight Loss (Cont`d)

No	LPS	Category	Analysis
3	Penghela		The level economy of neighbor residents are dominated with low income residents, it is likely that the residents having less excessive food in their daily garbage. The neighbor area also does not have any nearby restaurant/café/hotel that may dispose excessive food and beverages.
4	Simolawang		The level economy of neighbor residents are dominated with low income residents, it is likely that the residents having less excessive food in their daily garbage. Short length of garbage being piled from the residents garbage bin until transferred to LPS (normally the garbage men will collect it every one or two days) also becomes another reason. The waste collected here is also transported for 3 to 4 cycle each day, which minimize the formation of leachate.
5	Kemlaten	Medium	The population density in neighbor area is categorized as low density and the level economy is categorized as dominated with low income residents. It is supposed that there is not much of leachate produced in its solid waste generation. But due to long length duration of garbage being piled from residents garbage bin until being transferred to container in LPS (which can takes up to 3 to 4 days), the formation of leachate is high and the total amount of dropping leachate is high as well.
6	Kutisari PLN		The level economy of neighbor residents are dominated with medium and high income residents, it is likely that the residents having more excessive food in their daily garbage. The neighbor area also having some nearby restaurant/café/hotel that may dispose excessive food and beverages.

Table 7. 3 Analysis of The Amount of Weight Loss (Cont`d)

No	LPS	Category	Analysis
7	Kendangsari	High	The level economy of neighbor residents are dominated with medium and high income residents, it is likely that the residents having more excessive food in their daily garbage. The neighbor area also having some nearby restaurant/café/hotel that may dispose excessive food and beverages. The long length duration of garbage being piled from residents garbage bin until being transferred to container in LPS (which can takes up to 2 to 3 days), the formation of leachate is high. The physical condition of container also often found damaged and have many leaked spots which causing the leachate to drop.
8	Kembang Kuning		The level economy of half of the neighbor residents are dominated with medium and high income residents, it is likely that the residents having more excessive food in their daily garbage. The neighbor area also having some nearby restaurant/café/hotel that may dispose excessive food and beverages. The long length duration of garbage being piled from residents garbage bin until being transferred to container in LPS (which can takes up to 3 to 5 days), the formation of leachate is high. The physical condition of container also often found damaged and have many leaked spots which causing the leachate to drop.

Based on the analysis about the cause of dropping leachate total weight from each LPS during its transportation activity to TPA, it can be concluded that there are three factors that causing high amount of weight loss due to dropping leachate from container. The first is the type of garbage from restaurant/café/hotel is mostly dominated with organic waste which made up from the excessive food and beverages. The leachate formation is fast with the mix of organic waste inside container. Thus the area which having many nearby restaurant/café/hotel is likely to have more amount of weight loss.

The second is the economy level of neighbors' area that is dominated with medium income residents is likely to have more excessive foods in their daily garbage. This can fasten the formation of leachate inside the residents' garbage bin and when the waste being disposed as mix waste inside the container, the formation is even faster due to the increasing humidity inside the container. The third is the length duration of garbage being piled from residents garbage bin until being transported from LPS container. The longer length duration will cause the formation of leachate is faster and increased due to the temperature and humidity in the surrounded environment of the waste. The waste that is being kept too long in a closed area and being compacted will produce more leachate.

Furthermore, high amount of weight loss is caused by the formation of leachate from the waste kept inside the container. High category is likely found in the LPS that has wide served area which dominated with middle and high income residents. Combined with the availability of many nearby restaurant/café/hotel while the length duration of garbage being piled is long will causing the high amount of weight loss during transportation from LPS to TPA.

7.3 The Determination of New Solid Waste Density in LPS

The model to estimate the density of solid waste in LPS has been explained in previous chapter. It is then known that the parameters affecting the new solid waste density in LPS are depending on the weight of solid waste in TPA, the weight loss during the trip and the volume of solid waste generation inside the container. Having completing the gathering of all the required data, the solid waste density for each data is known and using software Monte Carlo, the distribution of the result is analyzed. Table 7.2 shows the result of each density of solid waste in LPS for every data gathered from sampling and experiment. The equation used is following equation 6.1 as mentioned as follow:

$$\text{SW Density in LPS} = \frac{SW\ Weight\ in\ LPS}{SW\ Volume\ in\ LPS}$$

$$\text{SW Density in LPS} = \frac{SW\ Weight\ in\ TPA + Weight\ Loss\ during\ Trip}{SW\ Volume\ in\ LPS} \quad \ldots\ldots (6.1)$$

Table 7. 4 Solid Waste Density in LPS

LPS	Day	Date	Rit	Volume in LPS (m3)	Weight in TPA (kg)	Weight Loss (kg)	Weight in LPS (kg)	Density in LPS (kg/m3)
Kendangsari	Senin	23	3	17.312	5080	35.615	5,115.615	**295.495**
	sabtu	21	1	16.557	5520	35.615	5,555.615	**335.544**
	Senin	23	2	17.553	5520	35.615	5,555.615	**316.505**
	jumat	20	3	18.354	5620	35.615	5,655.615	**308.147**
	Senin	23	1	18.2	5730	35.615	5,765.615	**316.79**
	minggu	22	3	18.385	5780	35.615	5,815.615	**316.323**
	minggu	22	1	19.608	5980	35.615	6,015.615	**306.793**
	kamis	19	3	18.023	6210	35.615	6,245.615	**346.535**
	selasa	17	3	18.471	6230	35.615	6,265.615	**339.213**
	selasa	17	2	19.896	6310	35.615	6,345.615	**318.939**
	Selasa	24	2	19.248	6490	35.615	6,525.615	**339.028**
	minggu	22	2	19.9146	6530	35.615	6,565.615	**329.688**
	rabu	18	3	20.376	6710	35.615	6,745.615	**331.056**
	Selasa	24	3	19.653	6870	35.615	6,905.615	**351.377**
Kutisari	Jumat	20	1	14.16	2460	20.852	2480.852	**175.201**
	Rabu	18	2	14.5495	5070	20.852	5090.852	**349.898**
	Sabtu	21	1	15.12	5090	20.852	5110.852	**338.019**
	Selasa	24	2	14.6345	5230	20.852	5250.852	**358.799**
	Kamis	19	2	15.12	5270	20.852	5290.852	**349.924**
	Rabu	18	1	15.006	5460	20.852	5480.852	**365.244**
	Minggu	22	1	14.616	5530	20.852	5550.852	**379.779**
	Selasa	17	2	15.251	6260	20.852	6280.852	**411.832**
	Senin	23	1	15.251	6420	20.852	6440.852	**422.323**
Dinoyo	jumat	20	1	15.639	2990	2.84	2992.840	**191.370**
	rabu	18	1	15.657	3060	2.84	3062.840	**195.621**
	sabtu	21	1	11.92	3060	2.84	3062.840	**256.949**
	sabtu	21	2	13.967	3180	2.84	3182.840	**227.882**
	selasa	17	2	13.687	3270	2.84	3272.840	**239.120**
	kamis	19	1	15.047	3540	2.84	3542.840	**235.451**
	kamis	19	2	15.62	3580	2.84	3582.840	**229.375**
	selasa	17	1	15.56	3740	2.84	3742.840	**240.542**
	Senin	23	1	14.805	3830	2.84	3832.840	**258.888**
	Selasa	24	1	14.582	3960	2.84	3962.840	**271.762**
	minggu	22	1	14.844	3970	2.84	3972.840	**267.639**
	rabu	18	2	16.674	4410	2.84	4412.840	**264.654**
	jumat	20	2	16.621	4520	2.84	4522.840	**272.116**
	Selasa	24	2	14.856	4560	2.84	4562.840	**307.137**
	Senin	23	2	19.152	5250	2.84	5252.840	**274.271**

Table 7. 5 Solid Waste Density in LPS (Cont`d)

LPS	Day	Date	Rit	Volume in LPS (m3)	Weight in TPA (kg)	Weight Loss (kg)	Weight in LPS (kg)	Density in LPS (kg/m3)
Indrapura	kamis	19	1	11.55	2680	2.805	2682.805	**232.275**
	rabu	18	1	12.075	3450	2.805	3452.804	**285.946**
	selasa	17	1	14.8395	3830	2.805	3832.854	**258.28**
	Selasa	24	1	10.857	4160	2.805	4162.805	**383.421**
	sabtu	21	1	15.936	4420	2.805	4422.805	**277.535**
	jumat	20	1	15.172	4950	2.805	4952.805	**326.443**
	Senin	23	1	16.007	5210	2.805	5212.805	**325.657**
Penghela	minggu	22	1	13.47238	3380	6.830	3386.829	**251.390**
	Senin	23	2	17.47222	4310	6.830	4316.829	**247.068**
	selasa	17	2	17.65395	4330	6.830	4336.829	**245.657**
	rabu	18	1	20.24235	4620	6.830	4626.829	**228.571**
	jumat	20	2	17.80543	4770	6.830	4776.829	**268.279**
	kamis	19	2	18.10038	4830	6.830	4836.829	**267.222**
	minggu	22	2	18.76225	4860	6.830	4866.829	**259.394**
	selasa	17	1	17.84475	4940	6.830	4946.829	**277.214**
	sabtu	21	2	16.45718	4970	6.830	4976.829	**302.410**
	rabu	18	2	20.77935	5000	6.830	5006.829	**240.952**
	sabtu	21	1	18.49545	5210	6.830	5216.829	**282.060**
	jumat	20	1	19.37544	5220	6.830	5226.829	**269.765**
	kamis	19	1	21.8907	5360	6.830	5366.829	**245.164**
	Selasa	24	2	16.96888	5410	6.830	5416.829	**319.221**
	Selasa	24	1	20.3175	5520	6.830	5526.829	**272.023**
	Senin	23	1	21.0025	5810	6.830	5816.829	**276.958**
Kembang Kuning	minggu	22	4	17.2935	3980	89.62	4069.623	**235.326**
	jumat	20	3	14.2338	5680	89.624	5769.623	**405.346**
	rabu	18	3	16.6425	5910	89.624	5999.623	**360.500**
	kamis	19	3	18.6795	6530	89.624	6619.623	**354.379**
	sabtu	21	1	15.4465	6800	89.624	6889.623	**446.031**
	selasa	17	1	18.46125	7110	89.624	7199.623	**389.985**
	minggu	22	1	18.6606	7150	89.624	7239.623	**387.963**
	Selasa	24	2	20.02875	7150	89.624	7239.623	**361.461**
	Selasa	24	4	20.37525	7190	89.624	7279.623	**357.277**
	Selasa	24	3	20.8635	7200	89.624	7289.623	**349.396**
	sabtu	21	2	18.88425	7400	89.624	7489.623	**396.606**
	kamis	19	1	18.7398	7420	89.624	7509.623	**400.733**
	jumat	20	2	18.69916	7490	89.624	7579.623	**405.347**
	rabu	18	2	20.7144	7540	89.624	7629.623	**368.326**
	Senin	23	1	18.67904	7630	89.624	7719.623	**413.273**

Table 7. 6 Solid Waste Density in LPS (Cont`d)

LPS	Day	Date	Rit	Volume in LPS (m3)	Weight in TPA (kg)	Weight Loss (kg)	Weight in LPS (kg)	Density in LPS (kg/m3)
	selasa	17	3	18.2133	7660	89.624	7749.623	**425.49**
	sabtu	21	3	20.118	7680	89.624	7769.623	**386.202**
	kamis	19	2	19.95525	7830	89.624	7919.623	**396.869**
	selasa	17	2	20.2671	7900	89.624	7989.623	**394.216**
	rabu	18	4	20.2725	8110	89.624	8199.623	**404.470**
	minggu	22	3	20.02875	8240	89.624	8329.623	**415.883**
	jumat	20	1	21.23625	8580	89.624	8669.623	**408.246**
	Senin	23	2	19.23096	8690	89.624	8779.623	**456.535**
	rabu	18	1	20.748	8810	89.624	8899.623	**428.938**
	minggu	22	2	20.2608	8830	89.624	8919.623	**440.240**
	Selasa	24	1	21.609	8970	89.624	9059.623	**419.253**
	Senin	23	3	21.23508	9400	89.624	9489.623	**446.884**
Simolawang	minggu	22	3	15.7253	3700	1.538	3701.537	**235.384**
	jumat	20	4	13.73088	3710	1.538	3711.537	**270.30**
	jumat	20	3	14.36436	3910	1.538	3911.537	**272.308**
	sabtu	21	3	14.96883	4200	1.538	4201.537	**280.685**
	rabu	18	1	14.43488	4210	1.538	4211.537	**291.761**
	kamis	19	2	14.94983	4230	1.538	4231.537	**283.049**
	jumat	20	2	14.52183	4310	1.538	4311.537	**296.900**
	kamis	19	4	16.25144	4420	1.538	4421.537	**272.070**
	Selasa	24	4	18.0564	4470	1.538	4471.537	**247.642**
	Senin	23	2	15.8741	4580	1.538	4581.537	**288.617**
	sabtu	21	2	14.99983	4640	1.538	4641.537	**309.439**
	selasa	17	2	15.04213	4840	1.538	4841.537	**321.865**
	selasa	17	3	14.67113	4840	1.538	4841.537	**330.004**
	minggu	22	2	18.13	4930	1.538	4931.537	**272.008**
	rabu	18	2	15.502	5300	1.538	5301.537	**341.996**
	Selasa	24	3	19.5761	5870	1.538	5871.537	**299.93**
Kemlaten	Rabu	18	1	15.86092	5880	11.213	5891.212	**371.429**
	Selasa	24	1	15.69464	5900	11.213	5911.212	**376.638**
	Senin	23	1	16.11292	7900	11.213	7911.212	**490.985**
	Kamis	19	1	16.85364	8310	11.213	8321.212	**493.733**
	Sabtu	21	1	17.51692	9050	11.213	9061.212	**517.283**

Knowing that the variables affecting solid waste density in LPS having uncertainty and can have different probabilities of different outcomes occurring, then it requires describing the data using probability distribution. Using Monte

Carlo software. Figure 7.1 presents the probability distribution that is best fit to describe the outcome of different solid waste density in LPS.

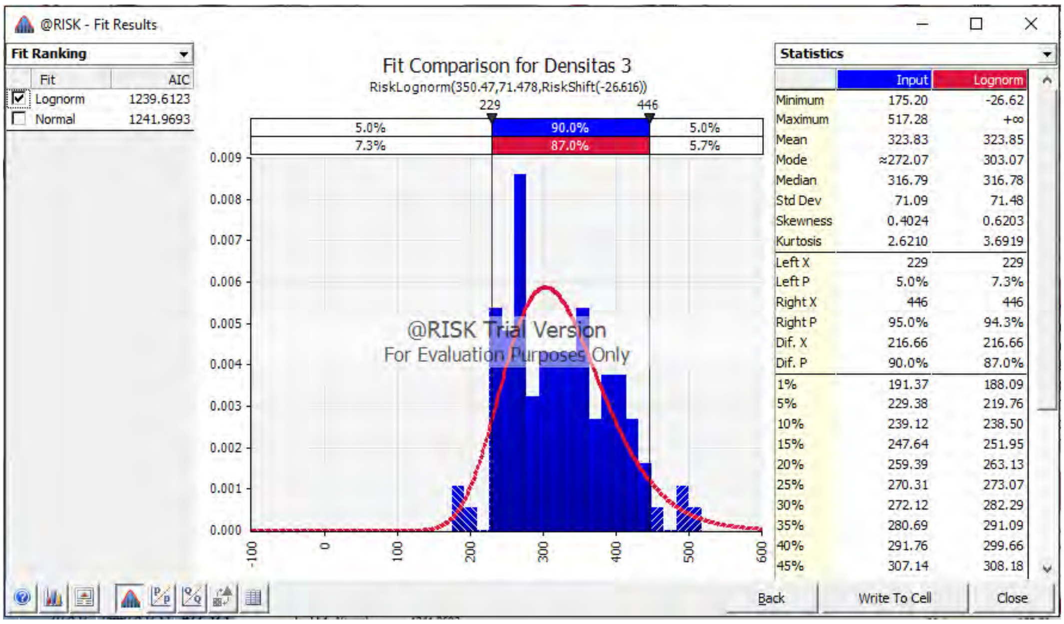


Figure 7. 1 Probability Distribution for the Outcome of Solid Waste Density in LPS

It is then known that the best fit distribution to describe the outcome is lognormal distribution. This distribution shows that the values are positively skewed, even though not symmetric like a normal distribution. It is used to represent values that do not go below zero but have unlimited positive potential. From the probability distribution graph, it shows that the data skewed to the density value with range about 272.07 until 323.83. It indicates that the value that may well represent the density of solid waste in overall LPS lies in between this range. Data parameters like mean, median and mode is known in the right side of the graph. With mean value 323.85 kg/m^3, median value 316.78 kg/m^3 and mode value 303.07 kg/m^3. These values lies in between the range, thus the range is reduced by picking up these values to be tested in the next measurement. Using error measurement by calculating the mean average percentage error (MAPE) from the density value in estimating the weight of solid waste in TPA when the volume is known, the estimated weight and the actual weight in TPA will be compared to get the MAPE score of each density value.

The MAPE score for mean value of density 323.85 kg/m^3 is 19.22%, the MAPE score for median value of density 316.78 kg/m^3 is 18.72%, and the MAPE score for mode value of density 303.07 kg/m^3 is 18.23%. It is known that the least MAPE score is when using mode value of density 303.07 kg/m^3 to estimate the weight of solid waste in TPA. However this value is not yet to be confirmed as the most appropriate value to represent solid waste density from the objected LPS in Surabaya Municipality. Somehow this value is neglecting the concern of LPS cluster because the test is not done specifically in each cluster. As comparison, another error measurement is done to test whether there`s another alternative of density values that can well representing the actual density of solid waste in LPS.

The next error measurement is done by calculating MAPE score when the solid waste weight of each cluster is estimated using its own specific density value. The example of the MAPE calculation in estimating the weight of solid waste weight from LPS Kendangsari is presented in table 7.3

Table 7. 7 MAPE Comparison between Single Non Specific Density and Varied Specific Density in LPS Kendangsari

LPS Kendangsari											
density - 303.07 kg/m3							specific density = 319.091 kg/m3				
Volume	Densitas Estimasi	Weight Loss	Berat TPA	Berat Estimasi TPA	MAPE		Densitas Estimasi	Weight Loss	Berat TPA	Berat Estimasi TPA	MAPE
17.312	303.070	35.615	5080	5,211.13	0.03		319.091	35.615	5080	5,488.49	0.08
16.557	303.070	35.615	5520	4,982.32	0.10		319.091	35.615	5520	5,247.58	0.05
17.553	303.070	35.615	5520	5,284.17	0.04		319.091	35.615	5520	5,565.39	0.01
18.354	303.070	35.615	5620	5,526.93	0.02		319.091	35.615	5620	5,820.98	0.04
18.2	303.070	35.615	5730	5,480.26	0.04		319.091	35.615	5730	5,771.84	0.01
18.385	303.070	35.615	5780	5,536.33	0.04		319.091	35.615	5780	5,830.87	0.01
19.608	303.070	35.615	5980	5,906.98	0.01		319.091	35.615	5980	6,221.12	0.04
18.023	303.070	35.615	6210	5,426.62	0.13		319.091	35.615	6210	5,715.36	0.08
18.471	303.070	35.615	6230	5,562.39	0.11		319.091	35.615	6230	5,858.32	0.06
19.896	303.070	35.615	6310	5,994.27	0.05		319.091	35.615	6310	6,313.02	0.00
19.248	303.070	35.615	6490	5,797.88	0.11		319.091	35.615	6490	6,106.25	0.06
19.9146	303.070	35.615	6530	5,999.90	0.08		319.091	35.615	6530	6,318.96	0.03
20.376	303.070	35.615	6710	6,139.74	0.08		319.091	35.615	6710	6,466.18	0.04
19.653	303.070	35.615	6870	5,920.62	0.14		319.091	35.615	6870	6,235.48	0.09
					6.963%						4.215%

The result shows that the error percentage is smaller when the weight of solid waste from LPS Kendangsari is estimated using specific density. The same calculation is done for the other LPS sampling location which representing each cluster. The result is presented in table 7.4.

Table 7. 8 MAPE Differences between Single Non Specified Density and Varied Specific Density

LPS	Varied Specific Density	MAPE Differences		Deviation
		Single Non Specific (303.07)	Varied Specific	
Kendangsari	319.091	6.96%	4.22%	2.75%
Kutisari	350.090	24.29%	16.78%	7.52%
Dinoyo	248.830	23.84%	10.23%	13.61%
Indrapura	278.430	14.02%	12.47%	1.55%
Penghela	265.840	15.46%	6.69%	8.77%
Kembang Kuning	395.020	24.44%	8.45%	15.99%
Simolawang	283.040	9.49%	7.47%	2.03%
Kemlaten	490.970	31.29%	13.66%	17.63%

From the comparison result, it can be concluded that there are two option of determining solid waste density in LPS in Surabaya Municipality. The option is between to use single non specific density with value 303.07 kg/m^3 or to use varied specific density according to the density from each cluster. The use of single non specific density is practically simpler, because then the density will be assumed that it can well representing the density of solid waste in all LPS in Surabaya Municipality. However there must be deviation and the inaccuracy in estimating the actual value. It may lead to the unfairness when it comes as the basis of payment such as the payment for solid waste transportation activity.

Regarding the use of varied specific density from each cluster, it is less practically simple to use compare to the non specific one. However realizing that the characteristics of LPS in generating solid waste differs from one another thus it is actually more appropriate to say that the solid waste density in LPS should be categorized according to the characteristics cluster. Then the error percentage when estimating the weight of solid waste is more accurate and reduced the deviation. It is also enable to close the gap of payment that should be given to partners to DKP and make it more fair by using the accurate basis of conversion.

7.4 Evaluation of Expenditure for Solid Waste Transportation

The new estimated density obtained in this research then will be used to evaluate the expenditure of solid waste transportation which done by DKP in the existing system. In the existing system, DKP converts the weight of solid waste transported to TPA in order to obtain the volume of solid waste being transported from LPS. However after conducting statistical analysis in the historical data of volume and weight of solid waste, and conducting observation in the LPS, it is known that the conversion factor is improperly used consistently. DKP management staff mentioned that the conversion factor used is 305 kg/m^3, but the result of error measurement shows the least error percentage is found when conversion factor 288.5 kg/m^3 in the majority of LPS. Thus the method to establish a new model to estimate the conversion factor is established in this research.

Having two kind of density as the option to determine the most appropriate conversion value, the comparison of cost estimation is done to check the fairness of payment when using the new estimated density. Table 7.3 shows the table used to compare the expenditure if using non specific density in LPS Kendangsari for period December 2015. While table 7.4 s shows the table used to compare the expenditure if using specific density in LPS Kendangsari for period December 2015.

Table 7. 9 Expenditure Comparison in LPS Kendangsari (December 2015)

Date	Weight TPA (kg)	Rit	Weight Loss (kg)	Estimated LPS Density (kg/m3)	Historical Volume LPS (m3)	Estimated Volume (m3)	Distance (km)	Unit Price (Rp m3.km)	Actual Cost (Rp)	Estimated Cost (Rp)
1	11720	2	35.61	303.07	40	39	34	1,493.00	Rp 2,030,480.00	Rp 1,974,944.32
2	23910	4	35.61	303.07	72	79	34	1,493.00	Rp 3,654,864.00	Rp 4,028,610.20
3	16980	3	35.61	303.07	52	56	34	1,493.00	Rp 2,639,624.00	Rp 2,861,920.89
4	17070	3	35.61	303.07	54	57	34	1,493.00	Rp 2,741,148.00	Rp 2,876,995.23
5	14650	3	35.61	303.07	56	49	34	1,493.00	Rp 2,842,672.00	Rp 2,471,663.00
6	17880	3	35.61	303.07	52	59	34	1,493.00	Rp 2,639,624.00	Rp 3,012,664.28
7	17330	3	35.61	303.07	56	58	34	1,493.00	Rp 2,842,672.00	Rp 2,920,543.32
8	18780	3	35.61	303.07	52	62	34	1,493.00	Rp 2,639,624.00	Rp 3,163,407.68
9	19490	3	35.61	303.07	56	65	34	1,493.00	Rp 2,842,672.00	Rp 3,282,327.46
10	15640	3	35.61	303.07	56	52	34	1,493.00	Rp 2,842,672.00	Rp 2,637,480.73
11	19340	3	35.61	303.07	54	64	34	1,493.00	Rp 2,741,148.00	Rp 3,257,203.56
12	17450	3	35.61	303.07	54	58	34	1,493.00	Rp 2,741,148.00	Rp 2,940,642.44
13	18980	3	35.61	303.07	54	63	34	1,493.00	Rp 2,741,148.00	Rp 3,196,906.21
14	16560	3	35.61	303.07	52	55	34	1,493.00	Rp 2,639,624.00	Rp 2,791,573.97
15	19450	3	35.61	303.07	54	65	34	1,493.00	Rp 2,741,148.00	Rp 3,275,627.76
16	20230	3	35.61	303.07	54	67	34	1,493.00	Rp 2,741,148.00	Rp 3,406,272.03
17	16890	3	35.61	303.07	52	56	34	1,493.00	Rp 2,639,624.00	Rp 2,846,846.55
18	18810	3	35.61	303.07	52	62	34	1,493.00	Rp 2,639,624.00	Rp 3,168,432.46
19	18150	3	35.61	303.07	56	60	34	1,493.00	Rp 2,842,672.00	Rp 3,057,887.30
20	17290	3	35.61	303.07	54	57	34	1,493.00	Rp 2,741,148.00	Rp 2,913,843.61
21	17070	3	35.61	303.07	54	57	34	1,493.00	Rp 2,741,148.00	Rp 2,876,995.23

Table 7. 10 Expenditure Comparison in LPS Kendangsari (December 2015) (Cont`d)

Date	Weight TPA (kg)	Rit	Weight Loss (kg)	Estimated LPS Density (kg/m3)	Historical Volume LPS (m3)	Estimated Volume (m3)	Distance (km)	Unit Price (Rp m3.km)	Actual Cost (Rp)		Estimated Cost (Rp)	
22	16470	3	35.61	303.07	54	55	34	1,493.00	Rp	2,741,148.00	Rp	2,776,499.63
23	18860	3	35.61	303.07	54	63	34	1,493.00	Rp	2,741,148.00	Rp	3,176,807.09
24	16820	3	35.61	303.07	54	56	34	1,493.00	Rp	2,741,148.00	Rp	2,835,122.07
25	16800	3	35.61	303.07	52	56	34	1,493.00	Rp	2,639,624.00	Rp	2,831,772.21
26	15850	3	35.61	303.07	54	53	34	1,493.00	Rp	2,741,148.00	Rp	2,672,654.19
27	15570	3	35.61	303.07	56	52	34	1,493.00	Rp	2,842,672.00	Rp	2,625,756.24
28	8200	2	35.61	303.07	40	27	34	1,493.00	Rp	2,030,480.00	Rp	1,385,370.17
29	21220	3	35.61	303.07	50	70	34	1,493.00	Rp	2,538,100.00	Rp	3,572,089.76
30	19180	3	35.61	303.07	52	64	34	1,493.00	Rp	2,639,624.00	Rp	3,230,404.74
31	9890	2	35.61	303.07	42	33	34	1,493.00	Rp	2,132,004.00	Rp	1,668,432.76
									Rp	83,452,728.00	Rp	89,737,697.09
										Cost Difference	**Rp**	**(6,284,969.09)**

Table 7. 11 The recapitulation of expenditure difference from each LPS sampling location for period December 2015 using density 303.07 kg/m^3

No	LPS	Actual Expenditure	Estimated Expenditure	Expenditure Difference
1	Kendangsari	Rp 83,452,728	Rp 89,737,697	Rp (6,284,969)
2	Kutisari PLN	Rp 30,725,940	Rp 41,093,102	Rp(11,093,102)
3	Dinoyo	Rp 31,972,512	Rp 30,065,901	Rp 1,906,610
4	Indrapura	Rp 16,918,528	Rp 13,418,888	Rp 3,499,639
5	Penghela	Rp 34,506,736	Rp 31,480,678	Rp 3,026,057
6	Kembang Kuning	Rp 110,712,420	Rp 113,414,861	Rp (2,702,441)
7	Simolawang	Rp 45,418,560	Rp 43,540,208	Rp 1,878,351
8	Kemlaten	Rp 17,248,968	Rp 16,427,926	Rp 821,041

Table 7. 12 The recapitulation of expenditure difference from each LPS sampling location for period December 2015 using density from each cluster

No	LPS	Actual Expenditure	Estimated Expenditure	Expenditure Difference
1	Kendangsari	Rp 83,452,728	Rp 85,232,124	Rp (1,779,396)
2	Kutisari PLN	Rp 30,725,940	Rp 36,202,396	Rp (5,476,456)
3	Dinoyo	Rp 31,972,512	Rp 34,276,018	Rp (2,304,018)
4	Indrapura	Rp 16,918,528	Rp 14,606,409	Rp 2,312,118
5	Penghela	Rp 34,506,736	Rp 35,889,442	Rp (1,382,706)
6	Kembang Kuning	Rp 110,712,420	Rp 87,014,941	Rp 23,697,478
7	Simolawang	Rp 45,418,560	Rp 46,621,435	Rp 1,202,875
8	Kemlaten	Rp 17,248,968	Rp 10,140,765	Rp 7,108,202

Using the single non specific density, the result shows that there are expenditure for three LPS which is Kendangsari, Kutisari PLN and Kembang Kuning are suppose to be more than the actual expenditure in period December 2015. It means that by using the new estimated density to determine the estimated volume as the basis payment, partners who done the transportation of solid waste from these three LPS should earn more from their works.

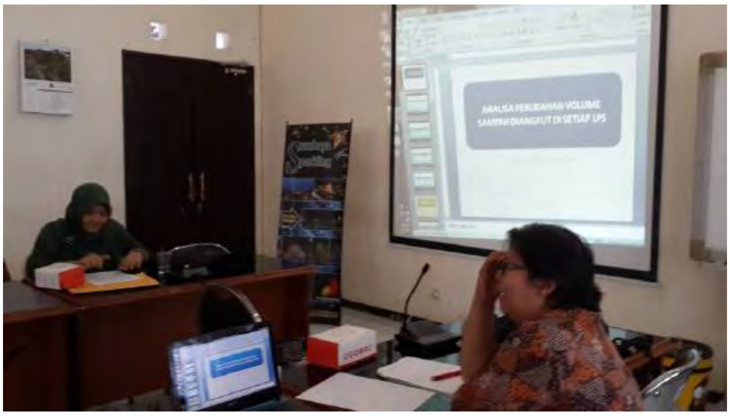
While for the other LPS, the result shows that the expenditure is suppose to be less than the actual expenditure in period December 2015. It means that by using the new estimated density to determine the estimated volume as the basis payment, partners who done transportation of solid waste from the other five LPS should earn less from their works.

The result when using varied specific density from each cluster shows that the extreme cost difference found in LPS Kembang Kuning which up to 23 million for one month payment is due to the wide gap between the conversion value used in historical data and the conversion value used in estimation. It shows that even though the solid waste density used as conversion factor is more accurate, but when it is applied to estimate volume, the result will not be fair for partners. Because in term of weight they have to carry the high amount of weight, but due to several factors written in this research such as the likeliness to step on the solid waste pile to make it more compact inside the container has reduced the actual volume. Thus it proves that using volume as basis of payment is causing unfairness.

ATTACHMENT

Attachment 1

Meeting and Discussion with DKP Management



Attachment 2

Sampling of Solid Waste Volume Measurement

Attachment 3
Experiment of Weight Loss

Attachment 4

Sources of Solid Waste in LPS

North Region

LPS Wonokusumo Kidul	
Cabang II Semampir	
1	endrosono
2	Wonosari
3	Wonosari tegal
4	endrosono
5	Wonosari
6	wonokusumo
7	wonokusumo kulon
8	wonokusumo makam
9	Wonosari tegal
10	wonokusumo kidul
11	Wonokusumo jaya
12	Wonokusumo jaya baru
13	wonosari
14	Wonosari lor
15	Wonosari mulyo
16	Wonosari wetan
17	tengg.
18	Tengg. Wetan
19	wonokusumo
20	Wonokusumo jaya
21	Tengg. Br. Mulyo
22	Tengg. Karya
23	Wonokusumo jaya
24	Tengg
25	Tengg. Br. Selatan
26	Wonokusumo lor
27	wonosari
28	Tengg. Br.
29	Wonokusumo jaya
30	Wonokusumo bakti
31	wonokusumo wetan
32	wonokusumo bakti
33	Tengg. Wetan
34	Wonosari baru
35	wonosari gg. KB.
36	Wonosari lor
37	Wonosari lor dalam
38	Wonosari lor wetan
39	Wonosari wetan
40	**Sumber Sampah**

RW	Kelurahan Wonokusumo
16	66,769
	4,173
4	16,692

LPS Bangunsari	
No	**Sumber Sampah**
1	Bangunrejo
2	Bangunrejo
3	Bangunsari
4	Perumahan Bandarejo

RW	Kelurahan Dupak
5	23,620
	4,724
2	9,448

LPS Krembangan Barat	
No	**Sumber Sampah**
1	Kemayoran baru
2	Krembangan baru
3	Krembangan selatan
4	Kalongan
5	Krembangan kidul
6	Kalongan
7	Kemayoran kauman
8	Krembangan jaya utara
9	Krembangan selatan
10	Krembangan selatan
11	Gatolitis
12	Kantor pos
13	Kemayoran budidaya
14	Koponiyen
15	Krembangan barat
16	Krembangan selatan
17	Krembangan selatan
18	Polretabes
19	Cendrawasih
20	Hotel IBIs
21	Adas Jl. Ketumbar
22	Krembangan buyut
23	Pasar krembangan
24	Perak timur

RW	Kel Krembangan Selatan
14	14,309
	1,022
10	10,221

North Region

No	Sumber Sampah	No	Sumber Sampah
LPS Benteng			
Cabang Pabean Cantikan			
No	**Sumber Sampah**		
Kelurahan Ampel		Kelurahan Nyamplungan	
1	Ampel	1	Jl. Panggung
2	Ampel	2	Kalimas Madya
3	Ampel	3	Kalimas udik
4	Ampel	4	Kalimas udik
5	Ampel	5	Kalimas udik
6	Ampel	6	Nyamplungan
7	Ampel kusumba	7	Nyamplungan
8	Ampel melati	8	Nyamplungan
9	Ampel Suci	9	Pertokoan panggung
10	Danakarya	Kelurahan Pegirian	
11	Danakarya	1	Karang tembok
12	Ketapang kecil	2	Karang tembok
13	KH Mas Mansyur	3	Pegirian
14	Pertukangan	4	Pegirian
15	Pertukangan	5	Pegirian
16	Sasak	6	Pegirian
17	Sasak	Sidotopo	
18	Sasak	1	Sidotopo
19	Sasak	2	Sidotopo
Kelurahan Ujung		3	Sidotopo pasar
1	Benteng	4	Sidotopo sekolahan
2	Benteng		
3	Hangtuah	**Kec. Semampir**	
4	Hangtuah	RW	Kel. Ampel
5	Sawah Pulo	17	20,028
6	Sawah Pulo	7	8,247
7	Sawah Pulo	RW	Kel. Ujung
8	Sawah Pulo	14	32,562
9	Sawah Pulo	5	11,629
10	Sawah Pulo	RW	Kel. Pegirian
11	Sawah Pulo	11	30,881
Kelurahan Perak Timu		3	8,422
1	Indrapura baru	RW	Kel. Sidotopo
2	Indrapura jaya	12	32,275
3	Jl. Johor	2	5,379
4	Johor lor	**Kec. Pabean Cantikan**	
5	Kalimas	RW	Kel. Perak Timur
6	Kalimas Barat	10	15,052
		3	4,516
		RW	Kel. Nyamplungan
		12	9,708
		4	3,236
			41,429

LPS Indrapura	
Cabang Pabean Cantikan	
No	**Sumber Sampah**
Kelurahan Krembangan Utara	
1	Depot Sampoerna
2	Kantor telkom
3	Kebalen
4	Pabrik Sampoerna
5	Sampoerna
Kelurahan Perak Timur	
1	Perak timur
2	Perak timur
3	Perak timur
4	Perak timur
5	Perak timur
6	Tambak Gringsig Baru
7	Tambak Gringsig Baru
8	Tambak Gringsig Baru
9	Tambak Gringsig Lama

LPS Babaan	
Cabang Pabean Cantikan	
No	**Sumber Sampah**
1	Kebalen
2	Kebalen Kulon
3	Jl Muteran
4	Dapukan
5	Jl Kelasi
6	Jl Kelantan
7	Jl Layar
8	Jl Perlis
9	Jl Johor
10	Pasar Babaan

RW	Kel Krembangan Utara
10	18,211
3	5,463
RW	Kel. Perak Timur
10	15,052
5	7,526
	12,989

RW	Kel Krembangan Utara
10	18,211
	1,821.10
5	9,105.50

East Region

LPS Semolowaru	
No	**Sumber Sampah**
Kelurahan Klampis Ngasem	
1	Klampis harapan
Kelurahan Medokan Semampir	
1	Ruko semolo
2	Semolo bahari
Kelurahan Semolowaru	
1	Semolo raya
2	Semolowaru indah
3	Semolowaru utara
4	Klampis semolo timur
5	Semolo pasar
6	Semolo selatan
7	Semolowaru selatan
8	Semolo tengah
9	Semolowaru indah
10	Klampis semolo tengah
11	Semolowaru blok
12	Semolowaru tengah
13	Klampis semolo
14	Semolowaru utara
15	Semolowaru utara
16	Semolowaru utara
17	Semolo utara
18	Semolowaru
RW	Kel. Klampis Ngasem
9	13,786
1	1,532
RW	Kel. Semolowaru
12	15,634
7	1,303
RW	Kel. Medokan Semampir
9	14,391
1	1,599
	4,434

LPS Klampis Jaya	
No	**Sumber Sampah**
1	Klampis sendang
2	Mleto
3	Wisma mukti
4	Deles
5	Klampis sendang
6	Ruko megah
7	Klampis ngasem
8	Klampis ngasem
9	Wisma mukti
10	Klampis ngasem
11	Klampis ngasem
12	Wisma Mukti
13	Wisma mukti
14	Klampis ngasem
15	SMAN 19
16	Tompotika
17	Wisma mukti
18	Klampis asem gang tembusan
19	Ruko 21
RW	Kel. Klampis Ngasem
9	13,786
7	1,532
	1,532

LPS Gebang Putih	
No	**Sumber Sampah**
Kelurahan Gebang Putih	
1	Gebang
2	Gebang ITS
3	Gebang kidul
4	Gebang
5	Gebang lor
6	Kertajaya indah timur
7	Gebang putih
8	Kertajaya indah timur
9	Kertajaya indah timur
10	Gebang putih
11	Kertajaya indah timur
12	Pasar Cosban
13	Pasar gebang
Kelurahan Manyar Sabranga	
1	Manyar kertoadi
2	Manyar kertoadi
3	Manyar sabrangan
4	Manyar tegal
RW	Kel. Gebang Putih
7	5,852
5	836
RW	Kel. Manyar Sabrangar
10	16,799
2	1,680
	2,516

East Region

LPS Kangean	
Cabang Pabean Cantikan	
No	**Sumber Sampah**
1	Jl Bali
2	Jl Biliton
3	Jl Jawa
4	Jl Kalimantan
5	Jl Raya gubeng
6	Jl Sumbawa
7	Jl Kertajaya
8	Jl Kertajaya selatan
9	Juwingan
10	Kertajaya/Juwingan
11	Jl Irian Barat
12	Jl Sulawesi
13	Jl Lombok
14	Jl Sumatera
15	Jl Sumatera Barat
RW	Kel. Gubeng
4	14,717
3	3,679

LPS Kendangsari	
No	**Sumber Sampah**
1	Kendangsari
2	Raya Kendangsari
3	Kendangsari
4	Kendangsari
5	Raya Kendangsari
6	Raya Kendangsari
7	Kendangsari
8	Tenggilis Mulyo
9	Kendangsari
10	Kendangsari
11	Kendangsari
12	Kendangsari
13	Kendangsari
14	Kendangsari
15	Kutisari
16	Kendangsari
17	Kendangsari
RW	Kel. Kendangsari
5	14,170
4	2,834

LPS Kutisari PLN	
No	**Sumber Sampah**
1	Kutisari Selatan
2	Kutisari Selatan
3	Kutisari Barat
4	Kutisari Utara
5	Kutisari Selatan
6	Kutisari Barat
7	Kutisari Utara
8	Kutisari Selatan
9	Kutisari Barat
10	Kutisari Utara
11	Kutisari Selatan
12	Kutisari Barat
13	Kutisari Utara
14	Kutisari Selatan
15	Kutisari Utara
16	Kutisari Selatan
17	Kutisari Barat
18	Kutisari Utara
19	Kutisari Selatan
20	Kutisari Barat
21	Kutisari Utara
22	Kutisari Selatan
23	Kutisari Utara
RW	Kel. Kutisari
6	17,859
6	2,977

LPS Tenggilis Mejoyo	
No	**Sumber Sampah**
1	Tenggilis Mejoyo
2	Tenggilis Mejoyo Selatan
3	Perum. Tenggilis Mejoyo
4	Tenggilis Mejoyo
5	Panduk
6	Tenggilis Mejoyo Selatan
7	Tenggilis Lama
8	Pondoboro
9	Tenggilis Utara
10	Tenggilis Mejoyo Selatan
11	Tenggilis Mejoyo
12	Tenggilis Mejoyo Selatan
13	Tenggilis Mejoyo
14	Pondoboro
RW	Kel. Tenggilis Mejoyo
6	10,260
4	1,710

East Region

LPS Rungkut Alang-alang	
No	**Sumber Sampah**
Kelurahan Kalirungkut	
1	Rungkut Lor
2	Rungkut Lor
3	Rungkut Lor
4	Rungkut Lor
5	Rungkut Kidul Industri
6	Rungkut Lor
7	Rungkut Asri
8	Rungkut Lor
9	Rungkut Asri Utara
10	Rungkut Lor
11	Rungkut Asri Utara
12	Rungkut Lor
13	Kaliwaru
14	Pasar Baru Rungkut
15	Pasar Soponyono
16	Rungkut Asri II
Kelurahan Rungkut Kidul	
1	Rungkut Asri Tengah
2	Rungkut Asri Tengah
3	Rungkut Asri Tengah
4	Rungkut Asri Tengah
5	Rungkut Asri Tengah
6	Rungkut Asri Tengah
RW	Kel. Kalirungkut
15	18,603
6	1,240
RW	Kel. Rungkut Kidul
12	10,876
2	906
	2,147

Penjaringan Sari	
No	**Sumber Sampah**
Kelurahan Kedung Baruk	
1	Wisma Kedungasem
2	Wisma Kedungasem
3	Wisma Kedungasem
Kelurahan Penjaringan Sari	
1	Penjaringan sari
2	Pandugo
3	Penjaringan sari
4	Pandugo
5	Pandugo
6	Penjaringan sari
7	Pandugo
8	Pandugo Projo
9	Penjaringan sari
10	Pandugo Projo
11	Penjaringan sari II,III,IV
12	Penjaringan sari
13	Rusun Penjaringan
RW	Kel. Kedung Baruk
10	13,127
2	1,313
RW	Kel. Penjaringan Sari
12	14,505
6	1,209
	2,521

Rungkut Menanggal Harapan	
No	**Sumber Sampah**
Kelurahan Gunung Anyar	
1	Gunung Anyar Kidul
2	Gunung Anyar Lor
3	Gunung Anyar Tengah
4	Gunung Anyar Kidul
5	Gunung Anyar Kidul
6	Gunung Anyar Harapan
7	Gunung Anyar Tengah
8	Gunung Anyar Harapan
9	Perum Graha Gunung Anyar
Kelurahan Rungkut Menanggal	
1	Rungkut Menanggal Harapan
2	Rungkut Barata
3	Rungkut Menanggal Harapan
4	Rungkut Barata
5	Rungkut Menanggal Harapan
6	Rungkut Menanggal Harapan
7	Rungkut Menanggal Harapan
8	Rungkut Mapan Selatan
9	Rungkut Mapan Selatan
10	Rungkut Menanggal Harapan
11	Rungkut Menanggal Harapan
12	Rungkut Menanggal Harapan
13	Rungkut Menanggal Harapan
14	Rungkut Menanggal Harapan
15	Pasar Rungkut Menanggal Harapan
RW	Kel. Gunung Anyar
8	18,494
4	2,312
RW	Kel. Rungkut Menanggal
4	12,987
4	3,247
	5,559

South Region

Cabang Sawahan		
LPS Kembang Kuning		
No	Volume	Sumber sampah
1	5.5	Kelurahan Pakis
2	7.5	
3	9.5	
4	9.5	
5	7.5	
6	11	
7	11.5	
8	12	
9	10	
	84	
RW	Kel. Pakis	
10	36,886	
9	3,689	

LPS Joyoboyo		
Cabang Wonokromo		
No	Volume	Sumber Sampah
1	15	**Kelurahan Sawonggaling**
2	6	
3	9	
4	6	
5	18	
6	12	
7	6	
9	9	
10	3	
11	6	
	90	
RW	Kel. Sawunggaling	
12	27,663	
10	2,305	

LPS Bendul Merisi		
Cabang Wonocolo		
No	Volume	Sumber Sampah
3	3	**Kelurahan Bendul Merisi**
4	1.5	
5	5.5	
6	6.5	
7	3	
8	3.5	
9	4.5	
10	6	
11	4.5	
12	6	
	44	
RW	Kel. Bendul Merisi	
12	15,967	
10	1,331	

LPS Karangpilang Marinir		
Cabang Karangpilang		
No	Volume	Sumber Sampah
1	5.5	Kelurahan Karangpilang
2	5	
3	7.5	
	18	

RW	Kel. Karangpilang	
4	9,320	
3	2,330	

LPS Waru Gunung I&II		
Cabang Karangpilang		
No	Volume	Sumber Sampah
1	7.5	Kelurahan Waru Gunung
2	7.5	
3	15	
	22.5	

RW	Kel. Waru Gunung	
3	8,189	
3	2,730	

LPS Babatan Indah		
Cabang Wiyung		
No	Volume	Sumber Sampah
1	3	Kelurahan Babatan
2	4	
3	4	
4	2	
	13	

RW	Kel. Babatan	
11	26,120	
4	2,375	

LPS Bogangin		
Cabang Karangpilang		
No	Volume	Sumber Sampah
1	14	Kelurahan Kedurus
RW	Kel. Kedurus	
9	25,326	
2	2,814	

LPS Kemlaten		
Cabang Karangpilang		
No	Volume	Sumber Sampah
1	3	Kelurahan Kebraon
2	3	
3	3	
4	2	
	11	
RW	Kel. Kebraon	
13	27,484	
4	2,114	

LPS Pagesangan		
Cabang Jambangan		
No	Volume	Sumber Sampah
1	5	Kelurahan Pagesangan
2	15	
3	14.5	
4	1	
6	10	
9	1	
	1.5	Pagesangan timu
	1	Masjid Akbar
	49	
RW	Kel. Pagesangan	
4	12,454	
4	3,114	

LPS Kebraon		
Cabang Karangpilang		
No	Volume	Sumber Sampah
1	1	Kelurahan Kebraon
2	7.5	
3	7.5	
4	5	
5	6	
9	4.5	
10	1.5	
11	3	
12	6	
	42	
RW	Kel. Kebraon	
13	27,484	
8	16,913	

Central Region

LPS Penghela	
Cabang Bubutan	
No	**Sumber Sampah**
Kelurahan Jepara	
1	Jl.Dupak Magersari
2	Jl.Dupak Timur
3	Jl.Dupak Timur
Kelurahan Peneleh	
1	Jl.Magersari
Kelurahan Gundih	
1	Gundih
2	Jl.Margodadi
3	Jl.Margodadi
4	Jl.Margorukun
5	JL.Margorukun
6	Jl.Margorukun
Kelurahan Bubutan	
1	Jl.Maspati
2	Jl.Maspati
3	Jl.Tembaan
Kelurahan Tembok Dukuh	
1	Jl.Semarang
Kelurahan Wonorejo	
1	Jl.Wonorejo
RW	Kel. Peneleh
16	14,427
1	902
RW	Kel. Gundih
10	28,560
3	2,856
RW	Kel. Bubutan
11	14,086
2	1,281
RW	Kel. Tembok dukuh
10	26,075
1	2,608
RW	Kel. Wonorejo
11	14,126
1	1,284
RW	Kel. Jepara
9	26,125
2	2,903
	11,833

LPS Simolawang			
Cabang Simokerto			
No	**Sumber Sampah**		
Kelurahan Gading		Kelurahan Sidodadi	
1	Dukuh setro 4	1	Jl.Kertopaten
2	Dukuh Setro II	2	Jl.Kampung Seng
Kelurahan Simolawang		3	Jl.Sidodadi gg 9
1	Jl.Simolawang	4	Jl.Sidodadi Kulon
2	Jl.Simolawang gg 1	5	Jl.Sidodadi gg 10
3	Jl.Banowati	6	Jl.Sidodadi
4	Jl.Sencaki	7	Jl.Sidodadi
5	Rumah Sususn Sombo	8	Jl.Sidodadi
6	Jl.Banowati	Kelurahan Simokerto	
7	Jl.Bolodewo	1	Jl.Simokerto
8	Jl.Simolawang	2	Jl.Kapasan
9	Rusun sombo	3	Jl.Sidotopo
10	JL Sidonipah Kalian	4	Jl.Simokerto
11	Jl.Bolodewo	5	Jl.Simokerto
12	Jl.Sidonipah	6	Jl.Simokerto
13	Jl.Simolawang	7	Jl.Simokerto
14	Rumah Susun Sombo	8	Jl.Kapasan
15	Jl.Bolodewo	9	Jl.Simokerto
16	Jl.Sidonipah	10	Jl.Kapasan Kidul
17	Jl.Simolawang	11	Jl.Simokerto
18	Jl.Simolawang		
19	Jl.Simolawang Baru		
20	Jl.Simolawang		
21	Jl.Simolawang	RW	Kel. Gading
22	Jl.Botopoteh	11	27,794
23	Jl.Sidonipah II	1	2,527
24	Jl.Sidonipah III	RW	Kel. Simolawang
25	Jl.Simolawang	8	22,368
26	Jl.Simolawang Baru	8	2,796
27	Rumah Susun Sombo	RW	Kel. Sidodadi
28	Rumah Susun Sombo	7	16,905
		4	2,415
		RW	Kel. Simokerto
		14	22,302
		5	1,593
			9,331

LPS Legundi	
Cabang Genteng	
Kelurahan Ketabang	
No	**Sumber Sampah**
1	Jl.Ambengan Plasa
2	Kediaman Walikota
3	Kediaman Wawali
4	Kusuma Bangsa
5	RS DKT
6	Seruni
7	SMA I Komplek
8	Jl.Kanginan
9	Jl.Walikota Mustajab
10	Jl.Ambengan
11	Jl.Ambengan
12	Jl.Kecilung
13	Jl.Kemuning
14	Jl.Melati
15	Jl.Slamet
16	Jl.Wijaya Kusuma
17	Jl.Jagung Suprapto
18	Jl.Kecilung
19	Jl.Magersari
20	Jl.Ketabang Margersari
RW	Kel. Ketabang
11	7,370
5	670

LPS Tambakrejo

Cabang Simokerto

No	Sumber Sampah		
Kelurahan Kapasan		Kelurahan Ploso	
1	Jl Donokerto	1	Jl Karang Asem
2	Jl Donorejo Buntu	2	Jl Karang Asem
3	Jl Kapasari	3	Jl Karang Empat
4	Ban Sepur Donorejo	4	Jl Karang Empat
Kelurahan Gading		Kelurahan Tanah Kali Kedinding	
1	Jl Kapas Baru	1	Jl Pogot Baru 10
2	Jl Gading 4	2	Jl Pogot gg 8
3	Jl Kapas Baru		
4	Jl Lebak Indah	Kelurahan Rangkah	
5	Jl Kapas Lor	1	Jl Rangkah
6	Jl Kapas Madya	2	Jl Rumah Sakit Suwandi
7	Jl Lebak Indah Utara	3	Jl Rangkah 7
8	Jl Lebak Jaya Timur	4	Jl Rangkah
9	Jl Lebak Rejo	5	Jl Rangkah Buntu
10	Jl Setro	6	Jl Rangka
11	Jl Setro Utara	7	Jl Rangkah
12	Jl Kapas Madya		
13	Jl Lebah Arum	Kelurahan Tambakrejo	
14	Jl Lebak Jaya Barat	1	Jl Tambak Arum
15	Jl Lebak Timur	2	Jl Tambak Bening
16	Jl Kapas Madya	3	Jl Tambak Bening
17	Jl Lebak Indah	4	Jl Tambak Rejo Pasar
18	Jl Kapas Madya Barat	5	Jl Tambak Arum
19	Jl Lebak Indah Utara	6	Jl Tambak Adi DKA
20	Jl Lebak Jaya	7	Jl Tambak Rejo
21	Jl Lebak Jaya Barat		
22	Jl Pasar Senggol	Kelurahan Simokerto	
23	Jl Setro	1	Jl Granting
24	Jl Kapas Baru	2	Jl Sidoyoso
25	Jl LebakJaya Timur	3	Jl Sidoyoso
26	Jl Pasar Setro	4	Jl Granting
27	Jl Setro Baru	5	Jl Granting Baru
28	Jl Gading 4	6	Jl Sidoyoso
29	Jl Kapas Baru	7	Jl Sidoyoso I
30	Jl Kapas Gading Karya	8	Jl Sidoyoso
31	Jl Kapas Jaya		
32	Jl Kapas Lor	RW	Kel. Kapasan
33	Jl Kapas Madya	9	15,398
34	Jl Kapas Madya Barat	2	1,711
35	Jl Lebak Jaya	RW	Kel. Gading
36	Jl Setro	11	27,794
37	Jl Kapas Gading Madya	11	2,527
38	Jl Kapas Madya	RW	Kel. Ploso
39	Jl Lebak Indah Utara	11	33,466
40	Jl Lebak Jaya	2	3,042
41	Jl Gading Arum	RW	Kel. Tanah Kali Kedinding
42	Jl Gading	12	50,487
43	Jl Kapas Baru	1	4,207
44	Jl Kapas Madya	RW	Kel. Rangkah
45	Jl Lebak Indah Mas	9	17,578
46	Jl Lebak Jaya 3	3	1,953
47	Jl Lebak Timur	RW	Kel. Tambakrejo
48	Jl Dukuh Setro	10	20,164
		4	2,016
		RW	Kel. Simokerto
		14	22,302
		4	1,593
			17,050

LPS Kayon

Cabang Genteng

No	Sumber Sampah
Kelurahan Embong Kaliasin	
1	Dispora
2	Jl.Kayun Permata
3	Kantor Kejaksaan
4	Pasar Bunga kayun
5	Jl.Embong Tanjung
6	Jl.Pemuda
7	Jl.Embong Kenonggo
8	Jl.Embong Gayam
9	Jl.Embong Trengguli
10	Jl.Embong Wunggu
11	Jl.Gubernur Suryo
12	Jl.Taman Simpang
13	Jl.Embong Cerme
14	Jl.Embong Kemiri
15	Jl.Embong Ploso
16	Jl.Sono Kembang
17	Ketupa
18	Jl.Taman Kayun
19	Jl.Basuki Rahmad
20	Jl.Embong blimbing
21	Jl.Embong Blimbing
22	Jl.Embong Blimbing
23	Jl.Embong Sawo
24	Jl.Kedondong Lor
25	Jl.Panglima Sudirman
26	Jl.Panglima Sudirman Timur
RW	Kel. Embong Kaliasin
12	12,637
9	1,053

LPS Dinoyo

Cabang Tegalsari

No	Sumber Sampah
Kelurahan Keputran	
1	Jl.Blambangan
2	Jl.Dinoyo
3	Jl.Keputran
4	Jl.Dinoyo Lor
5	Jl.Dinoyo
6	Jl.Dinoyo Baru
7	Jl.Dinoyo Tangsi
8	Jl.Dinoyo Tengah
9	Jl.Dinoyo VII
10	Jl.Dinoyo Sekolahan
11	Jl.Darmo Kali
12	Jl.Comal
13	Jl.Dinoyo Alun-Alun
14	Jl.Seayu
15	Jl.Dinoyo Sekolahan
16	Jl.Kapuas
17	Jl.Pajajaran
18	Jl.Raya Darmo
19	Jl.Sriwijaya
20	Jl.Kahuripan
21	Jl.Kejambon
Kelurahan Wonorejo	
1	Jl.Wonorejo
2	Jl.Wonorejo
RW	Kel. Keputran
6	16,234
6	2,706
RW	Kel. Wonorejo
11	14,126
1	1,284
	3,990

LPS Kedung anyar	
Cabang Tegalsari	
No	**Sumber Sampah**
Kelurahan Kedungdoro	
1	Jl.Kaliasin
2	Jl.Tegalsari
3	Jl.Surabayan
4	Jl.Kedung Klinter
5	Jl.Kaliasin Pompa
6	Jl.Kedungdoro
7	Jl.Kedung Rukem
8	Jl.Kedung Rukem
9	Jl.Kedung Klinter
10	Jl.Kaliasin Pompa
11	Jl.Plemahan
12	Jl.Plemahan Besar
13	Jl.Plemahan
RW	Kel. Kedungdoro
10	24,107
10	2,411

LPS Kedondong	
Cabang Tegalsari	
No	**Sumber Sampah**
Kelurahan Embong Kaliasin	
1	Jl Blimbing PKL
Kelurahan Tegalsari	
1	Jl Tegal Sari
2	Jl Pregolan
3	Jl Cempaka
4	Jl Mawar
5	Jl Cempaka
6	Jl Kampungmalang
7	Jl Kedondong
8	Jl Kampungmalang
9	Jl Kedondong
10	Jl Tegal Sari
11	Jl Kampungmalang
12	Jl Pregolan
Kelurahan Wonorejo	
1	Jl Kedung Sari
2	Jl Pandigiling
3	Jl Wonorejo
4	Jl Kejambon
5	Jl Wonorejo
RW	Kel. Tegalsari
7	17,608
7	2,515
RW	Kel. Wonorejo
11	14,126
2	1,284
	3,800

LPS Pasar Kembang	
Cabang Tegalsari	
No	**Sumber Sampah**
Kelurahan Kupang Krajan	
1	Jl.Kupang Krajan
Kelurahan Wonorejo	
1	Jl.Wonorejo
2	Jl.Wonorejo
3	Jl.Wonorejo II
4	Jl.Wonorejo III
5	Jl.Pasar Kembang
RW	Kel. Kupang Krajan
7	24,435
1	3,491
RW	Kel. Wonorejo
11	14,126
3	1,284
	4,775

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AUTHOR BIOGRAPHY

The author was born in Surabaya, 24 September 1994 with full name Rachmasari. Familiar with a nickname Rachma in her family, her friends and colleagues circles are better known to call her with nickname Ami. The author is the first child with one younger brother and one younger sister. The author academic record was started from Handayani Kindergarten,SDN Banyu Urip III/365 Surabaya, SMPN 4 Surabaya, and SMAN 5 Surabaya. In 2012 the author was officially enrolled in one of prestigious institution in Indonesia, as the student of Industrial Engineering (IE) in Faculty of Industrial Technology (FTI), Institut Teknologi Sepuluh Nopember (ITS) Surabaya. As the freshmen in the first year, the author has already involved in some organization activities in IE Department, such as Industrial Engineering Youth Club (IEYC) and Journalistic Community (J-Com). Having big interest in internationalization movement in ITS, the author decided to join as a volunteer in International Office (IO) ITS in her second year. At the same time, the author was also one of the board members of J-Com where she became part of the establishment of Unifier Magazine as the Coordinator of Articles. In the third semester, the author got selected as the Ambassador of ITS to join in a week program of International Cultural Exchange (ICE) 2012 held by Universiti Teknologi Malaysia (UTM) in Johor Bahru, Malaysia. Being a student who keen for opportunities to expand her global knowledge, the author was successfully being selected as one of the scholars to do one semester exchange program in Chulalongkorn University, Thailand. Spending her fifth semester studying in

Siam Country, the author returned to Indonesia to continue her study in ITS. The author was continuing her volunteering activity in ITS IO and had several experiences of becoming a project leaders and being involved in several specialized programs designed by ITS IO. In the seventh semester, the author got another opportunity to join as part of Student Association Ambassador to do Student Association Internship Program in University Kuala Lumpur, Malaysia. During the author last semester in ITS, she decided to focus more to work on her undergraduate thesis which was part of project in Dinas Kebersihan dan Pertamanan (DKP) Surabaya. The author can be contacted through her email address ami.rachmasari@yahoo.co.id or her linkedin profile www.linkedin.com/in/rachmasari-b250b6114 .